



OPERATIONS AND MAINTENANCE MANUAL
SOIL VAPOR EXTRACTION/AQUIFER AIR SPARGING
REMEDICATION SYSTEM
OLD NAVY FUEL FARM
NAVAL AIR STATION, BRUNSWICK, MAINE

Contract No. N62472-92-D-1296
Contract Task Order No. 0035



Prepared for

Department of the Navy
Northern Division
Naval Facilities Engineering Command
10 Industrial Highway
Mail Stop No. 82
Lester, Pennsylvania 19113-2090

Prepared by

EA Engineering, Science, and Technology
The Maple Building
3 Washington Center
Newburgh, New York 12550

February 1999
FINAL
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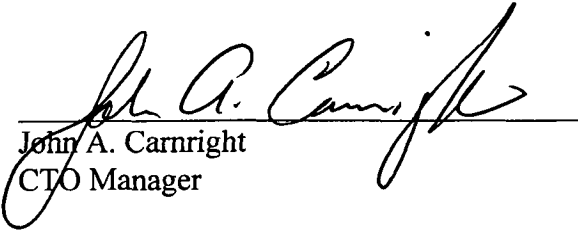
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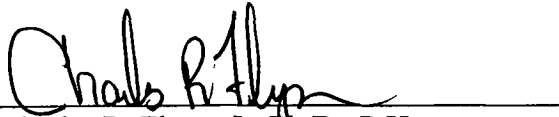
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John A. Carnright
CTO Manager

17 February 1999
Date


Charles R. Flynn, Jr. Ph.D., P.H.
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16 February 99
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QUALITY REVIEW STATEMENT

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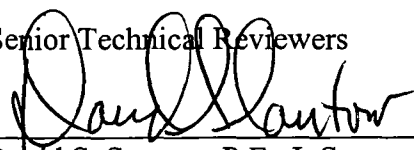
Description of Report/Deliverable:

Operations and Maintenance Manual, Soil Vapor Extraction/Aquifer Air Sparging
Remediation System, Old Navy Fuel Farm, Naval Air Station, Brunswick, Maine

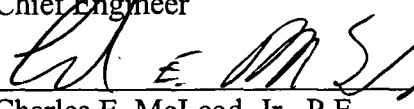
EA CTO Manager: John A. Carnright

In compliance with EA's Quality Procedures for review of deliverables outlined in the Quality Management Plan, this final deliverable has been reviewed for quality by the undersigned Senior Technical Reviewer(s). The information presented in this report/deliverable has been prepared in accordance with the approved Implementation Plan for the Contract Task Order (CTO) and reflects a proper presentation of the data and/or the conclusions drawn and/or the analyses or design completed during the conduct of the work. This statement is based upon the standards identified in the CTO and/or the standard of care existing at the time of preparation.

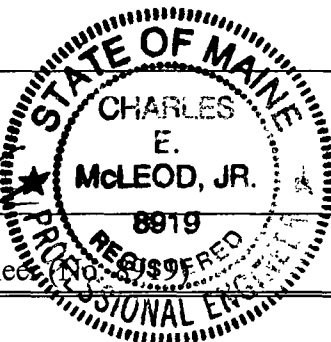
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1. INTRODUCTION

1.1 GENERAL

Under Contract No. N62472-92-D-1296, Northern Division, Naval Facilities Engineering Command issued Contract Task Order No. 0035 to EA Engineering, Science, and Technology to perform remedial system operations and monitoring for the soil vapor extraction/aquifer air sparge (SVE/AAS) system at the Old Navy Fuel Farm, Naval Air Station (NAS) Brunswick, Maine. The location of the subject site is shown on Figure 1-1 (as adapted from the Brunswick, Maine, U.S. Geological Survey 7.5-minute series topographic quadrangle map).

The primary purpose of the remediation system is to reduce volatile organic compound (VOC) concentrations in the local soil and ground water. To accomplish the stated objective, a system of SVE lateral trenches to remove soil vapor from the ground vadose zone, and an AAS system incorporating air sparge wells was designed and installed to deliver ambient air to the site ground water. Associated air delivery and vapor extraction return pipes are directed to a single treatment building housing the SVE and AAS mechanical and control equipment. A generic schematic of the SVE/AAS process is shown on Figure 1-2. However, due to high ground water at the reference site, normal SVE/AAS activities could not be accomplished. The system was operated as a sparging system to promote degradation of the VOC through biological activity. This activity was performed through December 1998. Modifications to the system were performed to allow normal SVE/AAS operations. These modifications are outlined in the Engineering Evaluation Report (EA 1999) and are incorporated into this manual.

1.2 SITE DESCRIPTION

The Old Navy Fuel Farm site is located on the northeast portion of NAS Brunswick grounds, and is bounded on the south by Fitch Avenue, on the west by 6th Street, and to the north and east by undeveloped land. The general site layout that constitutes the areas undergoing remediation via the SVE/AAS system is provided on Figure 1-3, and a process flow and instrumentation diagram is provided on Figure 1-4. The topography of the site area is characterized as flat and exhibits little relief. Surface grade consists of a level field of grass and paved access roads.

The SVE/AAS system treatment building is 1,350 ft² in size and is located on a concrete pad near the southwest end of the site. The system of SVE trenches and AAS wells occupy the area extending from the treatment plant to the north and northeast. In addition to the SVE and AAS systems, a total of 21 shallow well points and 11 ground-water monitoring wells exist in the general vicinity of the system (Figure 1-5).

1.3 SITE HISTORY

Prior to decommissioning in 1993, the Old Navy Fuel Farm consisted of two separate petroleum bulk storage tank farms which together included 9 mounded underground storage tanks. All underground storage tanks, piping, and associated appurtenances were removed during facility decommissioning.

Previous environmental investigations (O'Brien & Gere Engineers, Inc. 1990, 1992) identified two distinct dissolved-phase hydrocarbon plumes. The first plume is located in the east-central portion of the Old Navy Fuel Farm and appears to originate in the vicinity of a former JP-5 underground storage tank. The second dissolved-phase hydrocarbon plume is located in the north-central portion of the western half of the Old Navy Fuel Farm and appears to originate in the vicinity of former glycol tanks.

In 1995, construction of the remediation system with treatment plant was completed. On 13 June 1996, EA conducted a pre-startup engineering evaluation of the Old Navy Fuel Farm SVE/AAS remedial system, operated the air sparge system, and conducted sampling to evaluate system performance. In August 1996, active *in situ* bioremediation, using the AAS system only, was instituted to utilize biosparging technology for reduction of petroleum-related hydrocarbon concentrations in site soil and ground water. System modifications were made to the plant and field piping to enhance the AAS process. In December 1998, system modifications were performed to activate the SVE system. These modifications included a 2,000-gal moisture separator tank, level controls, and a process water pump.

1.4 PURPOSE AND SCOPE

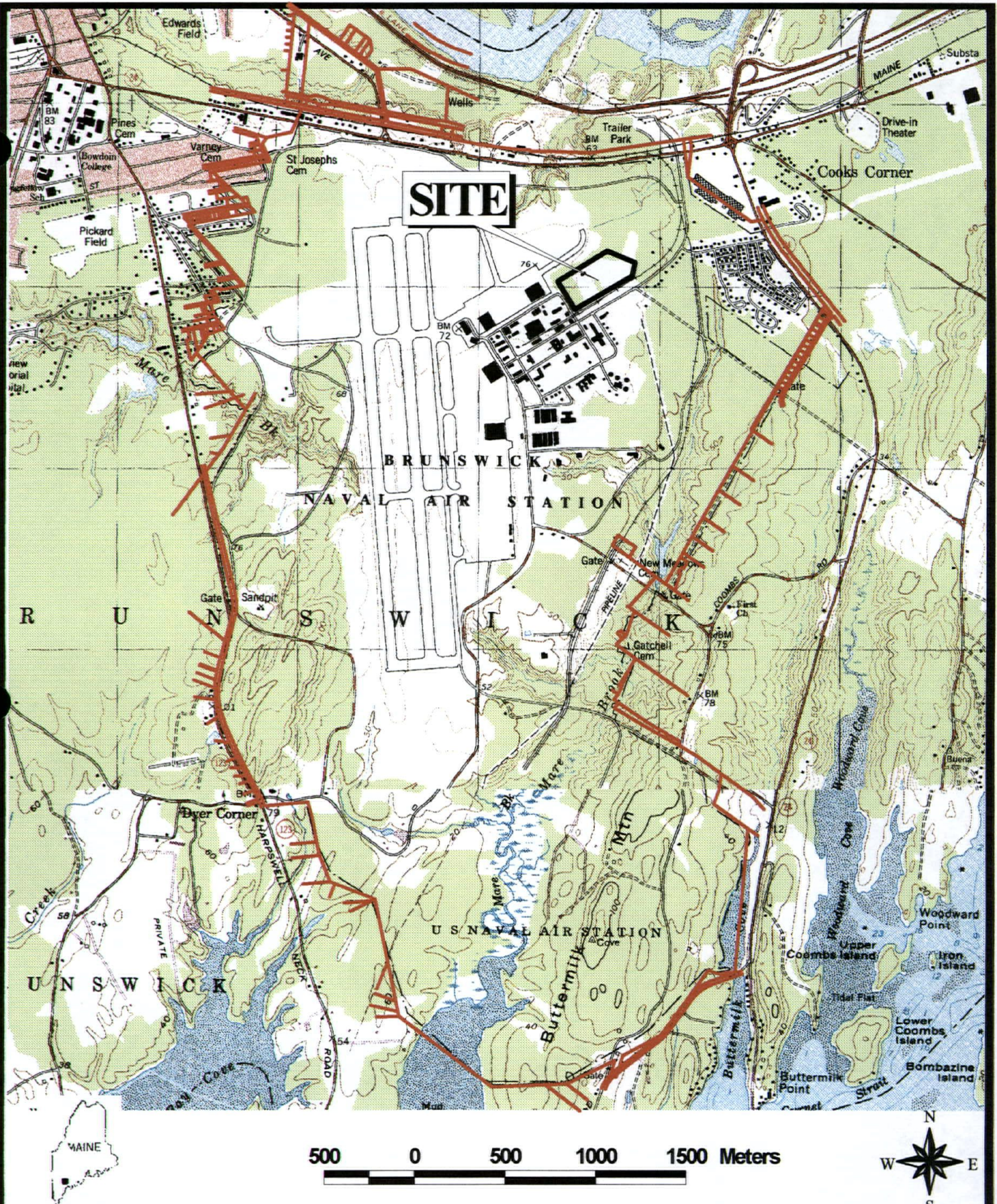
This Operations and Maintenance Manual is intended as a resource for personnel assigned to routine system performance monitoring, operations, and maintenance duties; responders to system faults or alarms; or for construction/retrofit. In November 1995, a preliminary Operations and Maintenance Manual entitled, *Preliminary Operations and Maintenance Plan for the Air Sparging/Soil Vapor Extraction System Fuel Farm Remediation* (OHM Remediation Services Corporation 1995) was issued. Selected site maps, figures, and technical descriptions for this document have been adapted from the above-referenced document.

This Operations and Maintenance Manual provides a description of the existing SVE/AAS system layout (including modifications), unit process and operational characteristics, and the periodic maintenance requirements for the mechanical system and support components. This Operations and Maintenance Manual is also intended to provide technical personnel with decision criteria associated with system startup, balancing and optimization, performance monitoring, fault isolation, troubleshooting, system re-start, and emergency response.

This Operations and Maintenance Manual is presented in the following sections:

- Chapter 1 Introduction
- Chapter 2 Unit Process Operation
- Chapter 3 Control Alarm Systems and Support Services
- Chapter 4 Air Sparging System Performance Monitoring and Sampling
- Chapter 5 Emergency Response Plan.

Selected unit process equipment figures and applicable manufacturer catalog information are provided in Appendix A. Appendix B contains the field data sheets used in system monitoring and sampling. Appendix C contains technical support and emergency contact telephone numbers, and emergency response route maps.



EA ENGINEERING,
SCIENCE, AND
TECHNOLOGY

OLD NAVY FUEL FARM
NAVAL AIR STATION
BRUNSWICK, MAINE

FIGURE I - I
SITE LOCATION MAP

PROJECT MGR

JAC

DESIGNED BY

BT

DRAWN BY

BT

CHECKED BY

CEM

SCALE

AS SHOWN

DATE

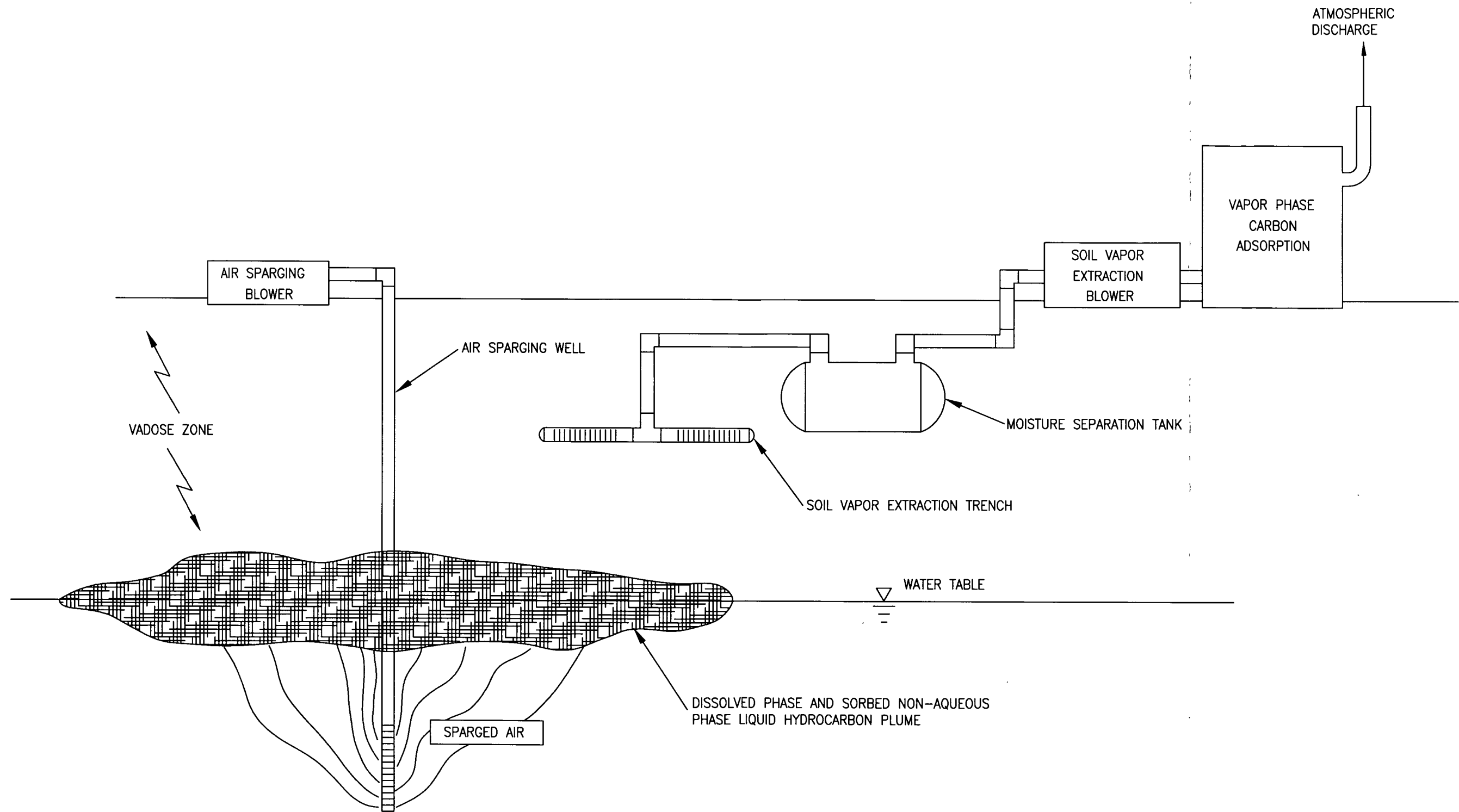
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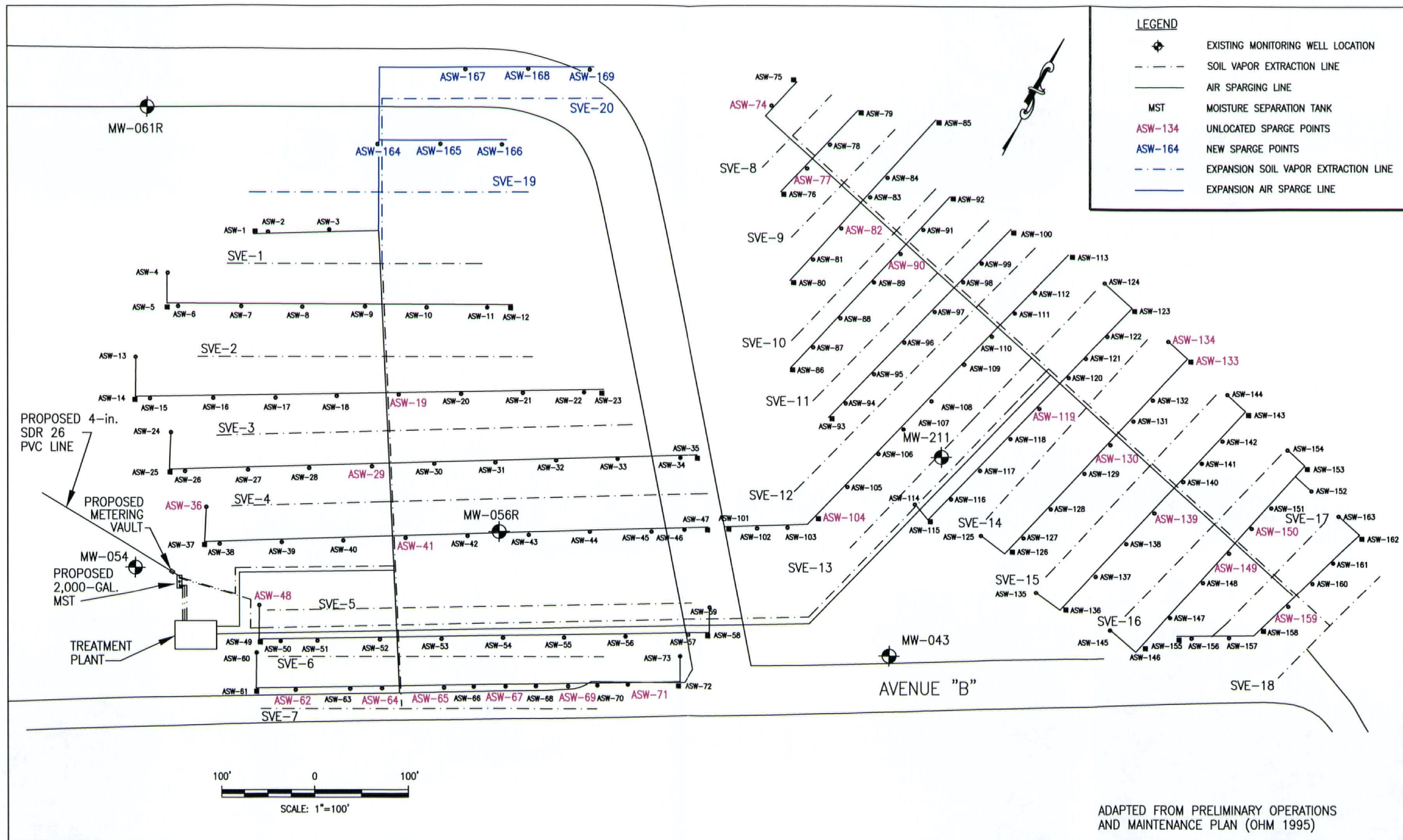
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DWG. FILE No. F:\CAD\29600\35\VF084\084\MAN\084_REV\FIG1-2.DWG



2. UNIT PROCESS OPERATION

2.1 AIR SPARGING SYSTEM

The air sparging or AAS system consists of 169 air sparge wells located throughout the remediation zone shown on Figure 1-3. Each air injection well is designed to provide for controlled injection of compressed air into the subsurface saturated zone. The air sparging system is designed to volatilize dissolved-phase hydrocarbons from the ground water and promote aerobic digestion via natural biodegradation. Typical air sparging well construction in the vadose zone is presented on Figure 2-1.

2.1.1 Air Sparging Air Injection Trenches and Piping

Seven air sparge lines (ASL) were installed to serve 73 air sparge wells in a branched system on the western zone of the area under remediation (Figure 2-2). Two additional ASLs were later installed to serve 6 additional air sparge wells in an effort to expand the remedial system to the north of the western portion of the system. In the western zone, a 4-in. polyvinyl chloride (PVC) main trunk line from the treatment plant supplies air to the 9 ASL laterals of 1.50-in. PVC piping for ASL-1 through ASL-7 and ASL-19 and ASL-20. The ASL laterals connect with each air sparge well which is constructed of 1-in. PVC well screen. Nine AAS vaults with control valves and ERDCO ARMOR-FLO[®] flowmeters are located at the 9 junctions within the main lateral line. Aboveground 1-in. ball valves were added at each sparge point to allow for increased flow control of the sparged air.

Eleven ASLs are installed to serve 90 air sparge wells in a branched system on the eastern zone of the area under remediation (Figure 2-2). In that section, a 3-in. PVC main trunk line from the treatment plant supplies air to the 11 ASL laterals of 1-in. PVC piping for ASL-8 through ASL-11 and 1.25-in. PVC piping for ASL-12 through ASL-18. The ASL laterals connect with each air sparge well which is constructed of 1-in. PVC well screen. Eleven ASL vaults each with a control valve and ERDCO ARMOR-FLO[™] flowmeter are located at the 11 air sparge junctions with the main lateral line. An aboveground 1-in. ball valve was added at each sparge point to allow for increased control of the sparge air during the current air sparging effort.

2.1.2 Air Sparging Process Flow

During air sparging operation, ambient air is drawn into the plant through a 6-in. diameter pipe on the treatment plant roof at a rate of approximately 900 cfm (300 cfm/blower) (Figure 2-3). Each blower system is set up to draw air through an intake silencer. Once in the plant, the intake airflow is run in parallel to flow through three blower systems (Gardner Denver Duroflow Blowers [air compressors] 45 Series designated C-1A, C-1B, and C-2) (Figure 2-4). From the blowers, the flow is directed through silencers and into 4-in. carbon steel piping (Figure 2-5). The three blower discharge lines are combined into two 4-in. PVC lines that go through the building wall and into two XCHANGER, Inc. Model AA-500 radiators (RAD-1 and RAD-2),

where heat is dissipated from the process stream to the ambient air. The discharge from the two radiators (Figure 2-6) is routed into two 4-in. PVC lines and to the sparge wells via the air sparge lines.

The air sparge blower and piping system is protected from overpressurization by mechanical pressure relief valves installed on the discharge side of each blower. The pressure relief valves are designed to actuate between 15-17 psi with relief airflow discharging inside the treatment building through a 2-in. carbon steel exhaust pipe. Pressure gauges are installed in-line with the pressure relief valves. The pressure gauges also provide test points for evaluating the condition of the pressure relief valves. A relief valve test may be performed by blocking ("valving-off") the discharge line to the air sparge manifold while observing the resulting rise in line pressure and the actuating point of the pressure relief valve.

The northern radiator routes the airflow to the western AAS system as shown on Figure 2-2. Air flow from the treatment building is distributed via Schedule 40 PVC piping going to the southeast via a 2.5-in. line that reduces to a 1.5-in. line to ASW-48 through ASW-73, and a 3-in. line which gradually reduces to a 1-in. line servicing ASW-1 through ASW-47 and ASW-164 through ASW-169.

The southern radiator routes air flow to the eastern AAS system as shown on Figure 2-2. Air flow from the treatment building is distributed via Schedule 40 PVC piping going to the northwest via a 2.5-in. line which gradually reduces to a 1-in. pipe servicing ASW-74 through ASW-134; to the southeast via a 2-in. line which gradually reduces to a 1-in. pipe servicing ASW-135 through ASW-163.

The AAS system will automatically shut down in the event of a control fault. The AAS blower motor is thermally protected and produces independent AAS system shutdown when an overheating condition exists. For restart procedures, refer to Section 2.1.5 and Table 2-1.

2.1.3 Air Sparging Process Equipment

The main AAS process equipment is located in the Old Navy Fuel Farm treatment building adjacent to the SVE equipment. The sources of compressed air for the air sparging system are three Gardner Denver Duroflow blower series CCDAABA air compressors.

The blowers (C-2, C-1A, and C-1B) are positive displacement rotary air blowers, belt-driven by a 20-HP electric motor, which produce 300 scfm at a pressure of 7 psig each. Each AAS blower is equipped with a 10-micron inlet particulate filter/silencer, a pressure relief valve, a discharge silencer, and associated temperature and pressure gauges. AAS equipment manufacturers' data and operations and maintenance data are provided in Appendix A.

2.1.4 Air Sparging Wells

Each air sparge well is constructed of 1-in. PVC slotted high-flow screen (at well bottom). The bottom of each screened section is completed with 6-in. unslotted PVC pipe and end cap. Sand pack is installed in the boring annulus from 6 in. below to 6 in. above the screened interval.

A minimum of 2 ft of bentonite seals the top of the sand pack. The remainder of the boring annulus is finished with cement-bentonite grout to approximately 3 ft below surface grade. The air sparge wells connect to the supply line via the 1-in. ball valves installed during air sparging activities.

2.1.5 Air Sparging System Operation

Startup of the AAS system is as follows:

1. Open the diversion valve (Figure 2-4) directing the flow to atmosphere. Opening the diversion valve allows unloaded start-up of the compressor.
2. Set the "Hand-Off-Auto" switch on the AAS control panel to the "Auto" position (Figure 2-7). AAS compressor will start as soon as the "Hand-Off-Auto" switch is turned from "Off" to "Auto." Table 2-1 provides the pre-operational inspection and AAS system start sequence before energizing control panel switch (HAND-OFF-AUTO). A pre-operational inspection checklist is provided in Appendix B and should be signed off each time the system is started.
3. After starting the compressor, let it accelerate to full speed. Enter the process equipment room and listen to the blowers for knocking sounds. If one of the blowers is exhibiting unusual noises, disconnect power at the unfused electrical disconnect mounted on the wall near the blower; then refer to procedures in Table 2-2.
4. If no problems are evident, partially close diversion valve (Figure 2-4), and operate for 5-10 minutes under low-load condition. Continue to close valve gradually and observe line pressures and temperatures. Continue operating the unit for 1 hour after which time all temperature readings should be stable and the diversion valve completely closed.
5. Inspect the flow and pressure gauges at the AAS well vaults. The flow gauge should indicate the values specified in Table 2-3 and Figure 2-2 for the western and eastern systems, respectively.
6. Flow rate fluctuations (typically decreases) are expected at air sparge wellheads during startup. Re-adjustment of flow may be necessary to maintain target injection rates. Typically, followup balancing is necessary once initial flow is established at all of the air sparge wells. Re-adjustment of flow is necessary if the value is 10 percent below the values specified in Table 2-3.

NOTE: The 1-in. ball valves have been previously adjusted to balance air flow; do not change the valve settings without Project Manager's approval.

Table 2-1 provides an AAS pre-start operation checklist and recommended startup sequence as a reference for operational personnel.

2.1.6 Troubleshooting

If one of the air sparge compressor blowers shuts down, the control panel lights will reflect AAS-Run and Failure conditions (Figure 2-7):

- Air Sparge Compressor Blower Running – 3 Green Lamps

These alarm and run status conditions are displayed on a view node via the Supervisory Control and Data Acquisition (SCADA) System located in Building 50. In the event of an alarm condition, the alarms are transmitted via radio to Building 50, and an audible alarm sounds to notify personnel of a fault condition.

Prior to restarting the air sparge compressor system, an inspection of the process equipment must be performed. Troubleshooting guidance for various operational symptoms is included in Table 2-2 (refer to Appendix A for more detailed technical guidance). Upon startup, observe the operational sequence presented in Section 2.1.5 above.

2.1.7 System Maintenance

Before starting maintenance procedures, turn off electrical power and completely depressurize the AAS system by opening the air diversion valves (Figure 2-4). **Do not attempt to remove, repair, or replace any component while it is under pressure.** Major periodic maintenance items include particulate filter cleaning or replacement, lubrication of the Gardner Denver Duroflow compressor, adjustment of belt alignment and tension, and pressure relief valve testing. Table 2-4 summarizes the essential periodic AAS system maintenance requirements.

A maintenance operational log, which lists when maintenance activities were accomplished, is provided in Appendix B. Detailed maintenance schedules and procedures for the Gardner Denver Duroflow compressor are found in Appendix A. Note that technical assistance by telephone is available directly through the Gardner Denver Machinery, Inc. Customer Service Department. Be prepared to provide unit serial numbers to assist the service department in identifying the specific equipment in service at the Old Navy Fuel Farm treatment building.

2.2 SOIL VAPOR EXTRACTION SYSTEM

The SVE system consists of underground lateral pipe assemblies located within the site remediation zone. The SVE piping layout is illustrated on Figure 2-8. The SVE system is designed to provide vacuum-induced removal of vapor-phase hydrocarbons from the vadose (unsaturated) zone soil. Soil vapor is withdrawn from the subsurface by regenerative blowers

(vacuum pumps) housed in the treatment building and then directed through carbon treatment vessels prior to atmospheric discharge. Because of a high ground water table within the area under remediation, the SVE system had to be modified to depress the ground water in order to capture the volatilized compound from sparging efforts as per the original design. The modifications have been completed, and the SVE system is now operational.

2.2.1 Soil Vapor Extraction Trenches and Piping

Two main SVE lines, one extending north of the treatment plant and one east, connect with 20 lateral SVE trenches. Nine of the 20 lateral SVE trenches cover the west side of the remediation area of the site while the remaining 11 cover the east side. The 2 northern-most lateral SVE trenches located on the west side were installed to collect the VOC vapors generated by the 6 additional sparge wells. Figure 2-8 shows the layout of the SVE systems. The SVE piping is aligned in such a manner as to intercept the migration of soil vapor resulting from continuous aquifer air sparging.

Each vent trench assembly consists of an interval of PVC slotted screen installed in lateral trenches extending approximately 3-4 ft below grade. In the western zone, the lateral trench assembly consists of 3-in. inner diameter Schedule 40 PVC piping in SVE trenches 4 and 5 and 2.5-in. piping in SVE trenches 1, 2, 3, 6, 7, 19, and 20. In the eastern zone, the lateral trench assembly consists of 2.5-in. inner diameter Schedule 40 PVC piping in SVE trenches 12 and 13; 2-in. piping in SVE trenches 10, 11, 14, 15, and 16; and 1.5-in. piping in trenches 8, 9, 17, and 18. An SVE vault with valve and ERDCO ARMOR-FLO™ flowmeter exists at each lateral vent trench connection with the main piping. Solid PVC vapor collection pipe, 6-in. inner diameter pipe from the western zone, and 4-in. inner diameter pipe from the eastern zone returns collected soil vapor and ground water to the treatment building via the 2,000-gal moisture separator tank (MST). Figure 2-9 presents a construction diagram of a typical lateral SVE assembly installation.

2.2.2 Soil Vapor Extraction Process Flow

The two SVE influent lines enter a 2,000-gal MST prior to entering the treatment building and connecting to the SVE process equipment (Figure 2-10). The 2,000-gal tank is buried to the north of the existing treatment building and the SVE lines from the field are plumbed directly to the flanges at the top of the tank. Lines then run from the tank to the SVE blowers in the treatment building. When the SVE blowers are started, a vacuum is pulled through the tank and out to the SVE fields. The ground water in the SVE pipes and the surrounding gravel pack is pulled through the lines and into the MST. After dewatering of the SVE pipes and gravel pack is completed, vapor can be collected by the system. The vapor phase is processed through carbon in the treatment building and the extracted ground water is pumped out of the tank and discharged into an adjacent sewer manhole, which will convey the process water to the Brunswick Sewer District. Controls provide shutdown of the SVE system in the event of excessive vacuum levels or a high liquid level within the MST. The alarm and status conditions are transmitted to Building 50 and are displayed via the SCADA view node.

2.2.3 Soil Vapor Extraction Process Equipment

The SVE process equipment includes vacuum pumps, a 2,000-gal MST, secondary moisture separators, and carbon adsorption units. Each system also incorporates particulate filters, flow control valves, pressure relief valves, silencers, pressure gauges, and flowmeters.

2.2.3.1 Soil Vapor Extraction Vacuum Pumps

Three Gardner Denver-Duroflow 45-Series, 460-volt, three-phase vacuum pumps (blowers) with 30 HP Toshiba motors, are utilized to extract soil vapors and ground water from the vadose zone (Figure 2-4). Two of the blowers, V1-A and V1-B, are rated for 750-cfm at 6.7 in. of mercury. The third blower, V2, is rated for 1,000 cfm at 6.7 in. of mercury. The blowers are individually mounted on steel skids with filters, silencers, vacuum relief valves, air dilution valves, air flow sensors, pressure gauges, vacuum gauges, and temperature gauges. Each blower is piped directly to the MST.

2.2.3.2 Moisture Separator Tank

The sti-P₃[®] (Steel Tank Institute), 2,000-gal MST is rated at 20-in. of mercury (maximum) vacuum and is equipped with seven 4-in. diameter flanged fittings and one 24-in. diameter access port. Four of the seven flanges are on one side of the access port (oriented toward the west during installation) and three are on the other (oriented toward the east) (Figure 2-10). The tank is buried below the frost line so that the top of the tank is 4 ft below grade to prevent the water that enters the tank from freezing. The tank is anchored by 4 concrete blocks to counteract the buoyancy forces exerted on the submerged tank (Figure 2-11). A 5-ft, 24-in. diameter riser pipe is attached to the flanged access port to allow aboveground access to the tank. A 1-in. diameter bung is located 6 in. from the top of the riser for the pump electric cable. The MST and associated equipment include a Cathodic Protection System to combat corrosion, a de-watering pump (KSB model KRTF40-160), an ECHOMAX ultrasonic level transducer for pump control, a Signet Model 2517 flow sensor and Model 8510 Compak flow transmitter, and a sampling port.

2.2.3.3 Flow Metering and Sampling Vault

A 3-ft diameter concrete vault houses a Signet Model 2517 insertion flow control valve and sampling port for the de-watering pump (Figure 2-11). The vault depth is a minimum of 4 ft below grade to prevent freezing. The discharge line is heat traced and insulated as an additional measure against winter conditions. A detail of the vault is shown on Figure 2-11. A 2-in. PVC ball valve was installed in-line for flow control. Flow measurements will be accomplished using a Signet Model 2517 flow sensor and Model 8510 Compak flow transmitter. The flow readings will be displayed locally and also transmitted to the SCADA system and displayed via the view node at Building 50.

2.2.3.4 Sanitary Sewer Discharge

The 2-in. force main is increased to 4-in. SDR 26 pipe after the flowmeters and sample vault. The 4-in. line is 4 ft below grade and conveys process water to the nearest sanitary sewer manhole. The base sanitary sewer collection system conveys this water to the Brunswick Sewer District for treatment. Based on negotiations with the Navy and the Brunswick Sewer District, it has been determined that the pumped ground water can be discharged directly to the sanitary sewer system without pretreatment provided the total petroleum hydrocarbon (TPH) concentration does not exceed the base wide discharge limit of 100 ppm.

The 4-in. SDR 26 force main was installed from the metering pit to a sanitary sewer manhole located approximately 250 ft south of Building 225 (Thrift Shop) in a dirt parking area. A 0.75-in. electrical conduit was installed to convey a 120-VAC signal from a Type F Mercury Ball float to the existing programmable logic controller (PLC). The signal from this float will be utilized to shut the system off and will be transmitted to the SCADA system and displayed via the view node in Building 50.

2.2.3.5 Moisture Separation System

An additional moisture separation system is designed into the SVE treatment process to provide for mechanical protection of the vacuum pumps against the entrainment of water droplets. This system is located inside the treatment building. Moisture-laden SVE process air enters a carbon steel moisture knock-out tank (45-gal capacity) located on the influent side of each SVE skid. The moisture knock-out tank is lined with polypropylene coalescing media, which enhances the formation and separation of water droplets. As the coalescing media becomes laden with (condensed) water droplets, the water falls to the bottom of the tank where it accumulates. A sight tube assembly is installed on the tank to allow visual monitoring of condensate volume. A liquid level switch limits the accumulation of water in the tank. The liquid level switch is wired to the SVE system control fault circuitry, creating a control fault when in the closed (contact) position. The control fault will occur when the volume of the tank reaches approximately 30 gal. The high-liquid level control fault cannot be cleared until the condensate is drained from the tank. The tank is fitted with a 0.75-in. ball valve, and flexible discharge tubing drain port that is piped to a sump located in the treatment building. Manually drained condensate is pumped from the sump into the force main and to the sanitary sewer.

Condensate volume should be monitored routinely during operations and maintenance visits and should be drained periodically. In order to drain the MST, it is necessary to interrupt the operation of the SVE blower and allow the system vacuum to return to zero. Draining is accomplished by opening the 0.75-in. ball valve and draining the condensate into the floor sump.

To return the SVE system to operation, return the drain valve to the closed position and restart system in accordance with Section 2.2.4. The sump (3 ft × 3 ft × 1 ft) in the floor of the treatment plant is fitted with a Jabsco Model No. 1673-100, 1/3-HP, sump pump.

2.2.3.6 Activated Carbon Adsorption System

Soil vapor generated from SVE operations is treated by five activated carbon adsorption vessels prior to discharge to the atmosphere. Each carbon adsorption vessel, a Carb-Clean Model V-140-4, is designed a maximum flow of 500 cfm, a maximum material operating temperature of 180°F, a maximum carbon operating temperature of 100°F, and a pressure drop under 5 in. water column at 500 cfm. Each vessel has a capacity of 140 lb of activated carbon (General Carbon Corporation Type GC C-30). Each vessel is equipped with a pressure gauge, 4-in. diameter inlet and outlet ports with sampling ports, and a 0.75-in. drain. Once treated, the vapor is discharged through the treatment plant roof via two piped outlets. The flow is split prior to carbon treatment and then discharges through 8-in. and 6-in. outlets.

2.2.4 Soil Vapor Extraction System Operation

Table 2-5 provides an SVE pre-start operational checklist and startup sequence as a reference for operational personnel. A pre-operational inspection checklist is provided in Appendix B and should be signed off each time the system is started.

The startup/restart sequence for SVE operation is as follows:

1. Ensure that the valves for the SVE lines are open.

NOTE: If the valves have been previously adjusted to balance air flow, do not change the valve settings upon a restart.

2. Open the air dilution valves located on the suction of each blower.

Caution should be observed if startup is occurring following an extended inoperable period. High influent total volatile hydrocarbon concentrations may be present and may require dilution by addition of atmospheric air. Operational personnel should discuss this possibility with the Project Manager, Site Leader, or other technical support personnel listed in Chapter 5.

3. At the main control panel, **turn the SVE “HAND/OFF/AUTO” switch to the “AUTO” position, and depress the start button to energize the SVE blower (Figure 2-7).** Energizing the SVE blowers establishes vacuum to the remediation zones as modulated by individual valve settings at the SVE influent manifold. All electrical SVE fault devices and the electronic liquid level sensor in the moisture separator are now energized.
4. After starting the blower, let it accelerate to full speed. Enter the process equipment room and listen to the blowers for knocking sounds. If one of the blowers is exhibiting unusual noises, disconnect power at the unfused electrical disconnect mounted on the wall near the blower; then refer to procedures in Table 2-6.

5. If no problems are evident, partially close the dilution valve (shown on Figure 2-4) and operate for 5-10 minutes under low-load condition. Increase vacuum gradually and observe line vacuums and temperatures. Continue operating the unit for 1 hour after which time all temperature readings should be stable.

Caution should be observed when starting the SVE system. Upon startup, the flow of ground water into the 2,000-gal MST, located to the north of the treatment building, will be higher than normal. The operator must monitor influent and effluent flow rates. The operator may have to adjust the air dilution valve to increase or decrease vacuum while initial dewatering occurs. This would be performed in order to prevent the 2,000-gal MST from filling with ground water and shutting the system down.

6. Inspect the flow and vacuum gauges at the SVE vaults. The flow gauge should indicate the values specified in Table 2-7 and Figure 2-8 for the western and eastern systems, respectively.
7. Flow rate and vacuum fluctuations (typically decreases) are expected in SVE lines during startup. Re-adjustment of flow and vacuum may be necessary to maintain target injection rates. Typically, followup balancing is necessary once initial flow is established at the extraction trenches. Re-adjustment of flow is necessary if the value is 10 percent below the values specified in Table 2-7 and Figure 2-8.

2.2.5 Troubleshooting

Operational/fault shutdown indication lights provided on the main control panel are listed as follows (Figure 2-7):

- SVE Process Blower Running – 3 Green Lamps
- Knockout Tank High Level – 3 Red Lamps
- SVE Process Blower Low Air Flow – 3 Red Lamps.

These alarm and run status conditions are displayed via the SCADA system located in Building 50. In the event of an alarm condition, the alarms are transmitted via radio to Building 50, and an audible alarm sounds to notify personnel of a fault condition.

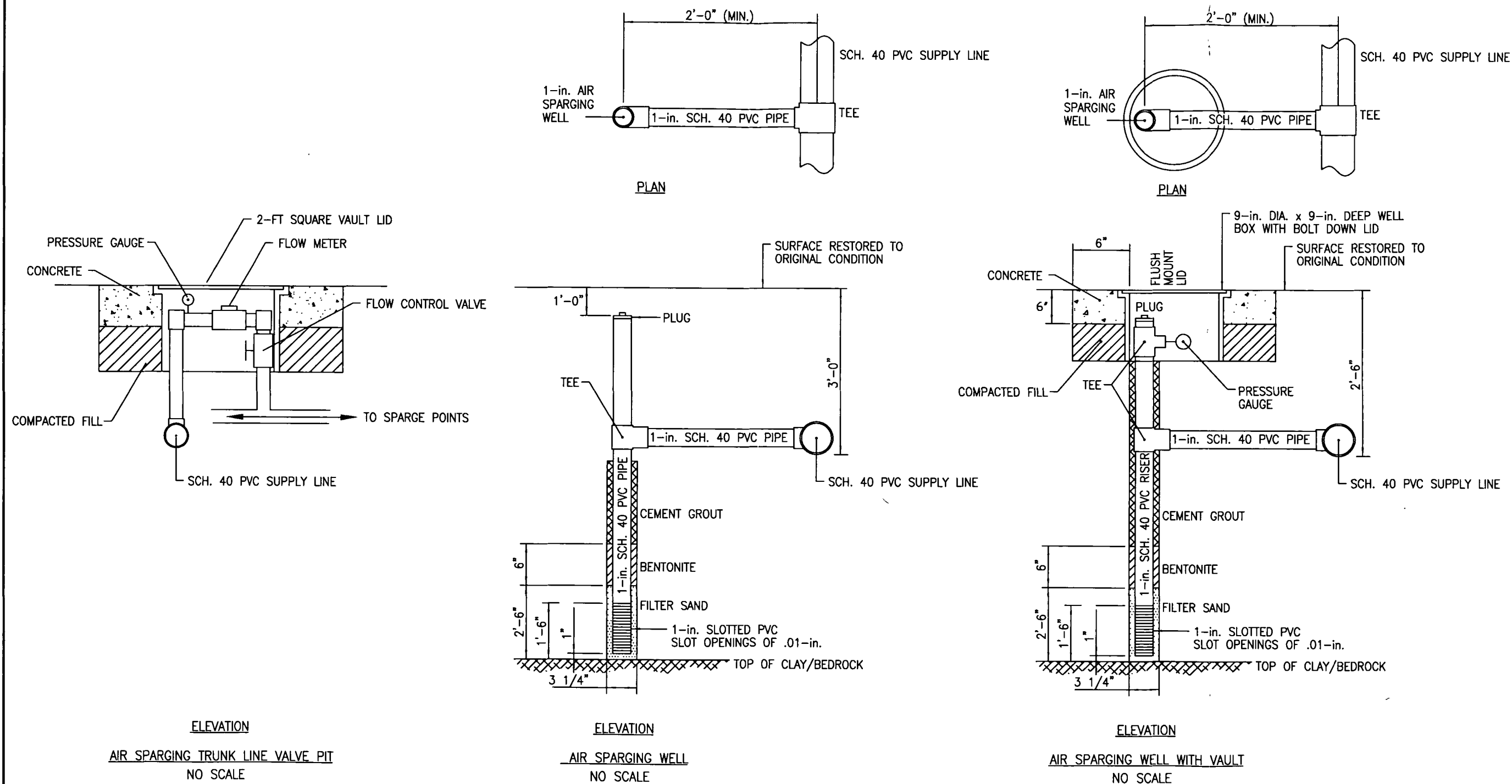
In response to SVE process shutdowns, operational personnel must initiate fault diagnosis/isolation efforts, followed by appropriate corrective actions. These efforts should include use of general troubleshooting tables provided in this Operations and Maintenance Manual. Table 2-6 summarizes several potential malfunctions related specifically to the SVE blower units. Refer to the manufacturer's literature provided in Appendix A for more detailed troubleshooting guidance. Operators should also consult project management/technical support personnel (Chapter 5) prior to restarting the SVE system.

2.2.6 Soil Vapor Extraction System Maintenance

The SVE treatment system requires periodic oversight and routine maintenance for continued satisfactory equipment performance. Equipment requiring routine (scheduled) maintenance includes the SVE moisture separator, particulate filters, and blowers. Table 2-8 summarizes items requiring periodic maintenance, frequency, and action. A maintenance operational log, which lists when maintenance activities were accomplished, is provided in Appendix B.

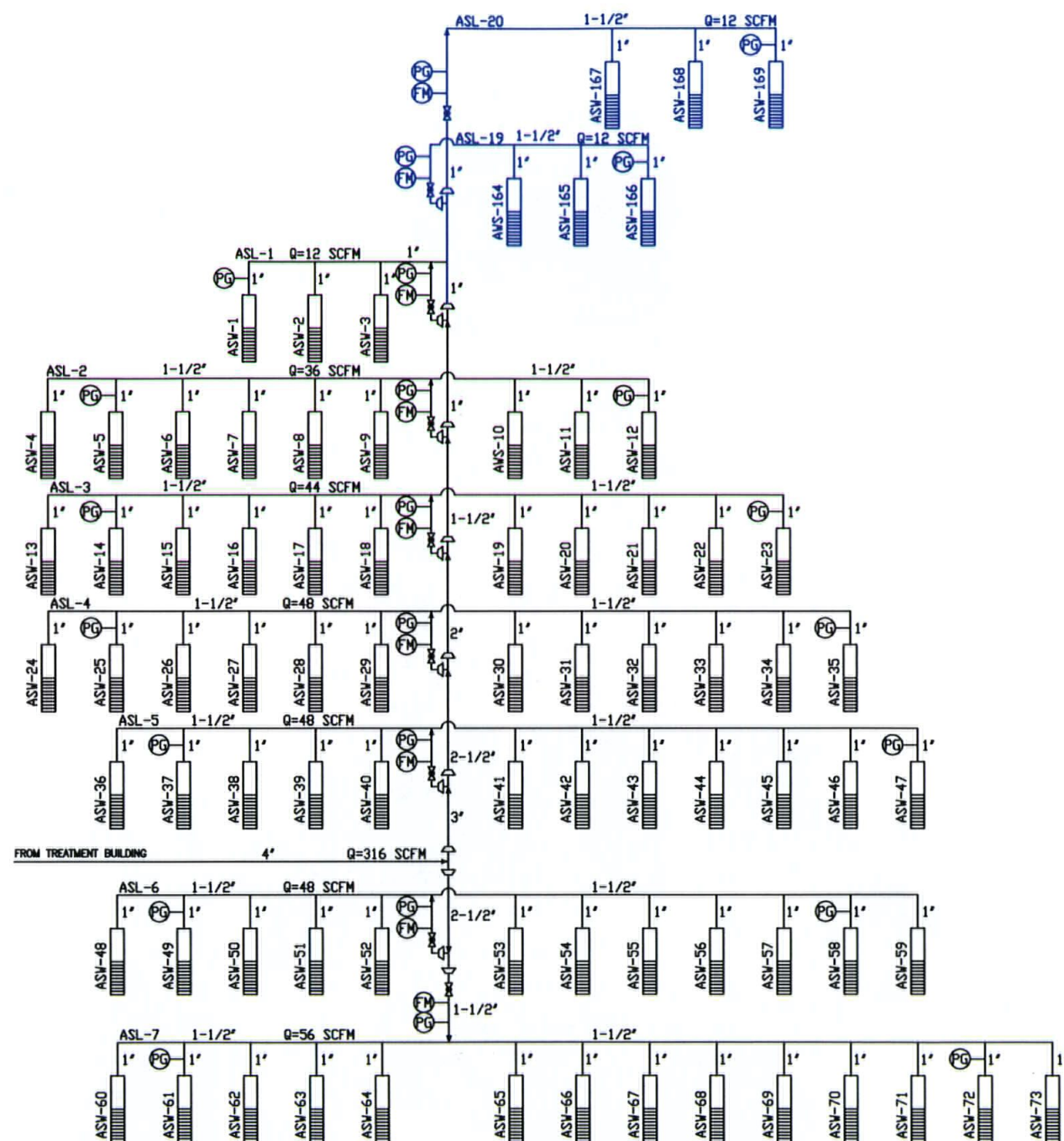
Replacement of the granular activated carbon adsorptive media is scheduled as needed based upon combined VOC concentrations in off-gas emissions. Carbon replacement should occur when the total VOC emission approaches either the maximum daily or hourly allowable concentration. This involves a subcontracted service with direct EA oversight. Additional maintenance tasks include general upkeep of the building and adjacent grounds, replacement/repair of damaged service vault components, inspection and testing of electrical mains (switch gear), circuit breakers, and confirmation of control fault function. Inspection and testing of alarm and status conditions should be performed on a quarterly basis unless the frequency of alarm conditions warrants an increased frequency.

SVE maintenance is accomplished in accordance with the equipment manufacturer's specifications (Appendix A) or in response to operational abnormalities observed during routine inspections. Routine inspections of the SVE system are accomplished during system performance monitoring and sampling events, as described in Chapter 4. During maintenance inspections, SVE equipment should be inspected for overall condition and operation. Visual checks for excessive vibration, wear, or leaks should be made. Excessive noise should be noted and investigated/reported. Condensate fluid levels should be checked. Particulate filters should be inspected and changed at the manufacturer's suggested interval (Appendix A).

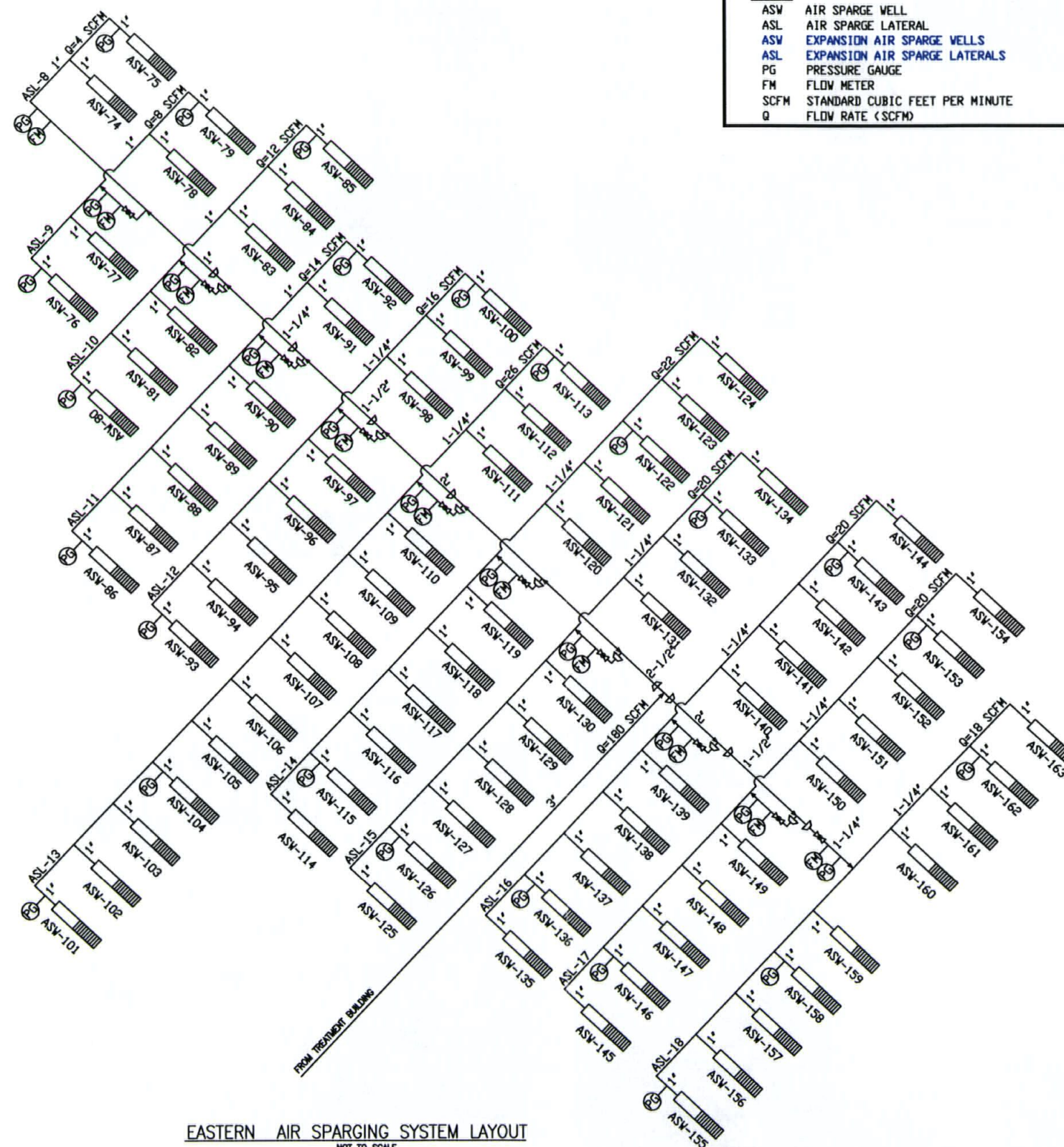


ADAPTED FROM PRELIMINARY OPERATIONS
AND MAINTENANCE PLAN (OHM 1995)

- LEGEND
- ASW AIR SPARGE WELL
 - ASL AIR SPARGE LATERAL
 - ASV EXPANSION AIR SPARGE WELLS
 - ASL EXPANSION AIR SPARGE LATERALS
 - PG PRESSURE GAUGE
 - FM FLOW METER
 - SCFM STANDARD CUBIC FEET PER MINUTE
 - Q FLOW RATE (SCFM)



WESTERN AIR SPARGING SYSTEM LAYOUT
NOT TO SCALE



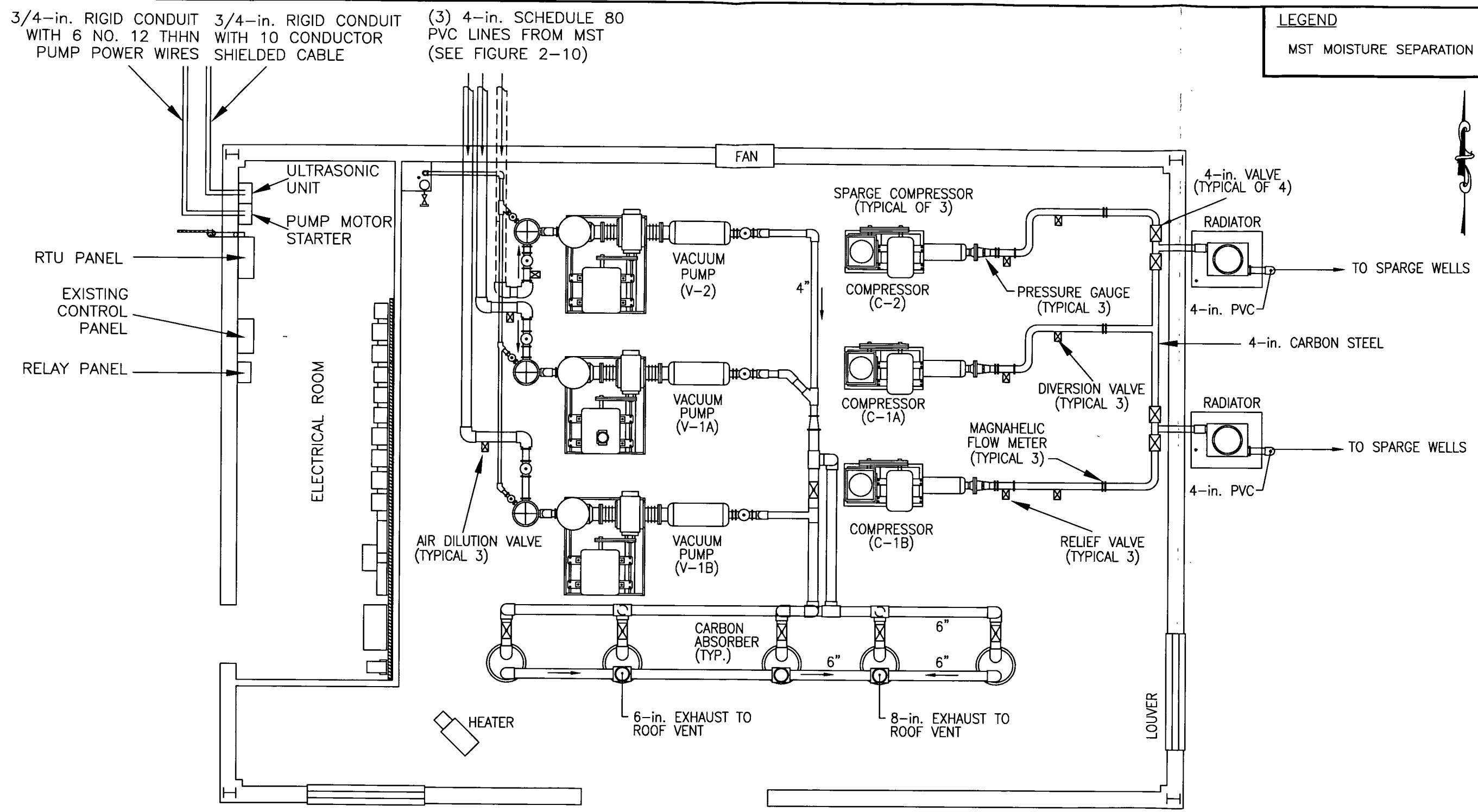
EASTERN AIR SPARGING SYSTEM LAYOUT
NOT TO SCALE

ADAPTED FROM PRELIMINARY OPERATIONS
AND MAINTENANCE PLAN (OHM 1995)



Figure 2-3. Exterior of treatment building.

LEGEND
MST MOISTURE SEPARATION TANK



ADAPTED FROM PRELIMINARY OPERATIONS AND MAINTENANCE PLAN (OHM 1995)

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|--|--|--|---|-------------|--------------|------------|-------------|-----------|
| | <p>EA ENGINEERING, SCIENCE, AND TECHNOLOGY</p> | <p>OLD NAVY FUEL FARM NAVAL AIR STATION BRUNSWICK, MAINE</p> | <p>FIGURE 2-4 MECHANICAL EQUIPMENT ROOM AND ELECTRICAL ROOM LAYOUTS</p> | DESIGNED BY | DRAWN BY | DATE | PROJECT NO. | FILE NAME |
| | | | | CEM | SAP | 5 JAN 1999 | 29600.35 | FIG 2-4 |
| | | | | CHECKED BY | PROJECT MGR. | SCALE | DRAWING NO. | FIGURE |
| | | | | DSS | JAC | NONE | - | 2-4 |

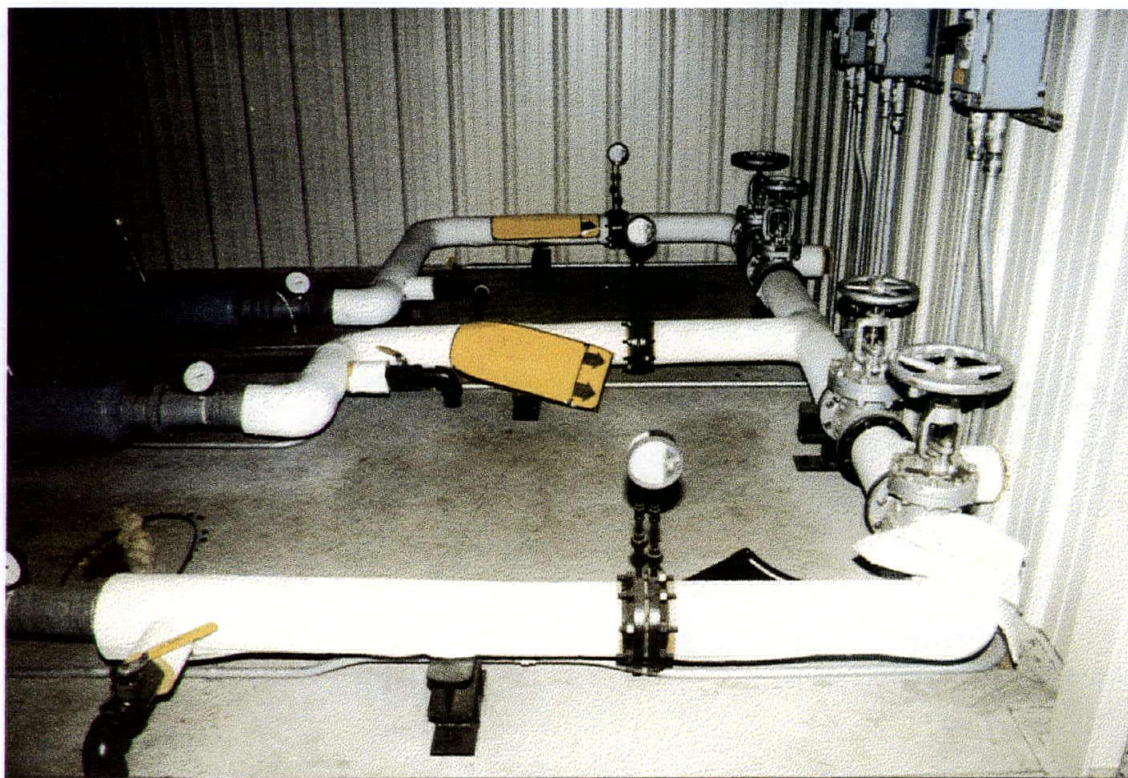


Figure 2-5. Aquifer air sparge discharge pipe valving system.

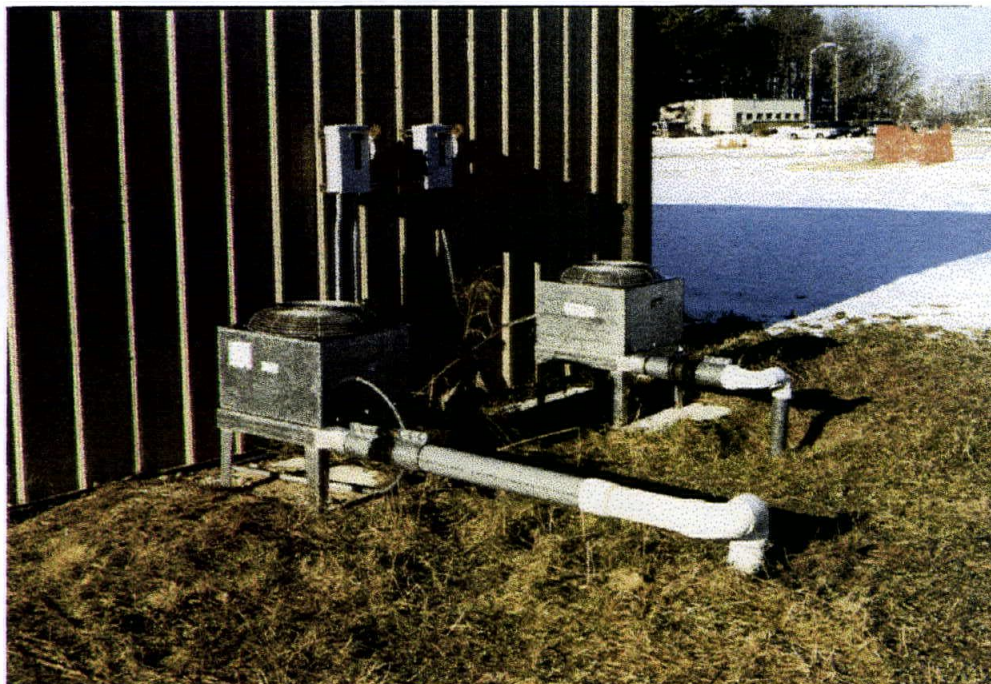
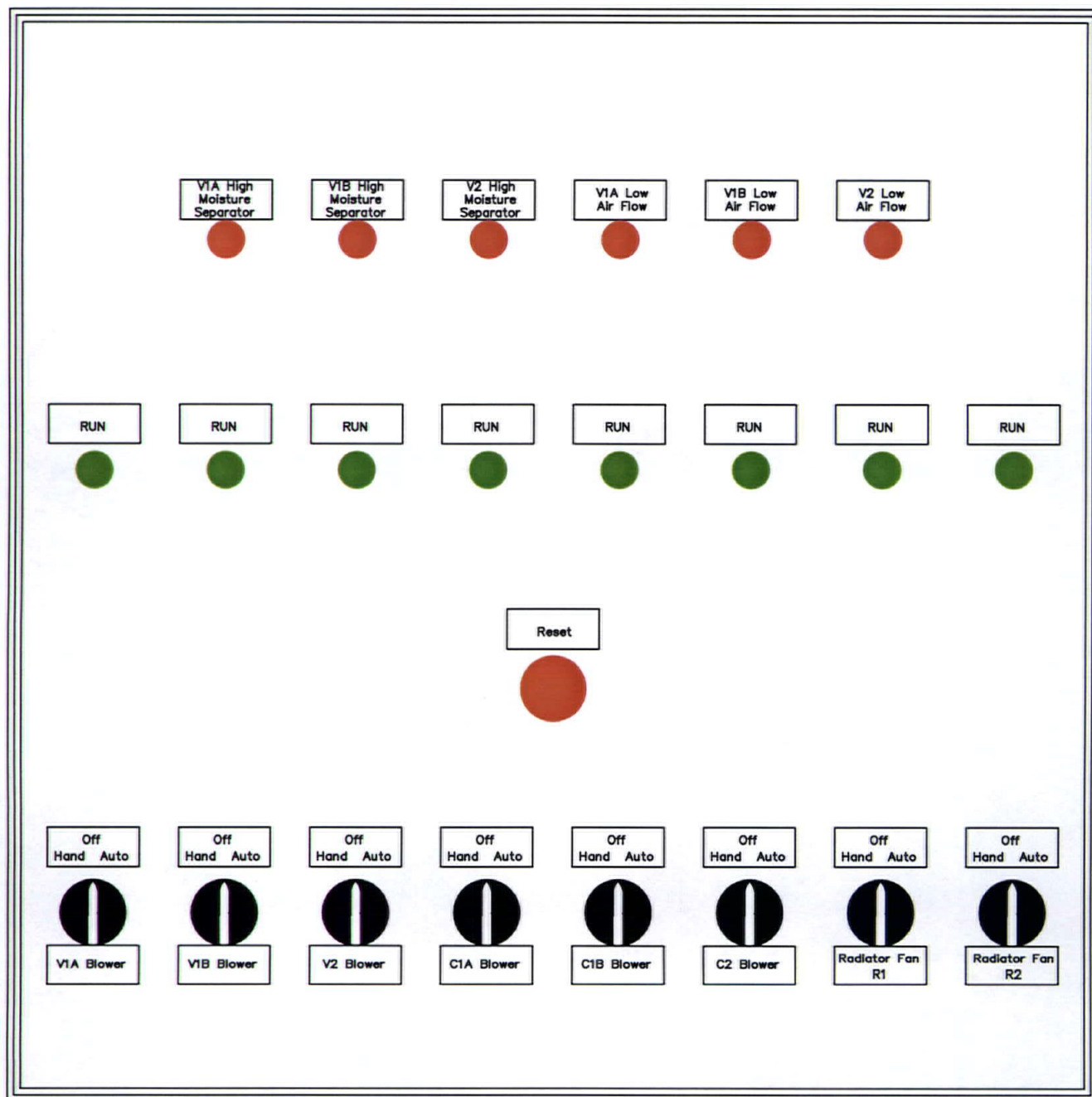


Figure 2-6. Photo of exterior view radiators.



DWG. FILE No. F:\CAD\29600\35\FD&M\O&M_MAN\O&M_REV\FIG2-7.DWG



EA ENGINEERING,
SCIENCE, AND
TECHNOLOGY

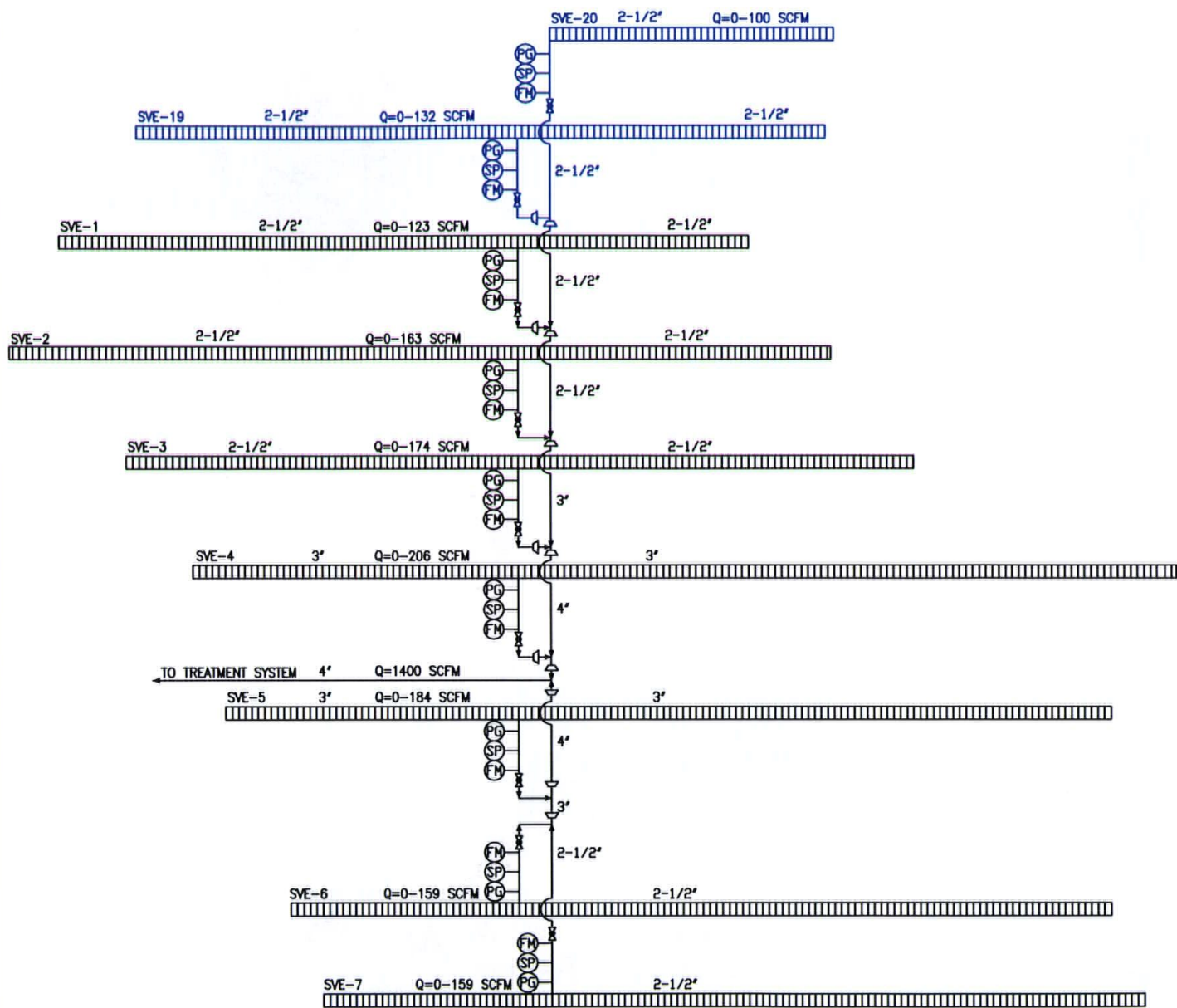
OLD NAVY FUEL FARM
NAVAL AIR STATION
BRUNSWICK, MAINE

FIGURE 2-7
TREATMENT SYSTEM CONTROL PANEL

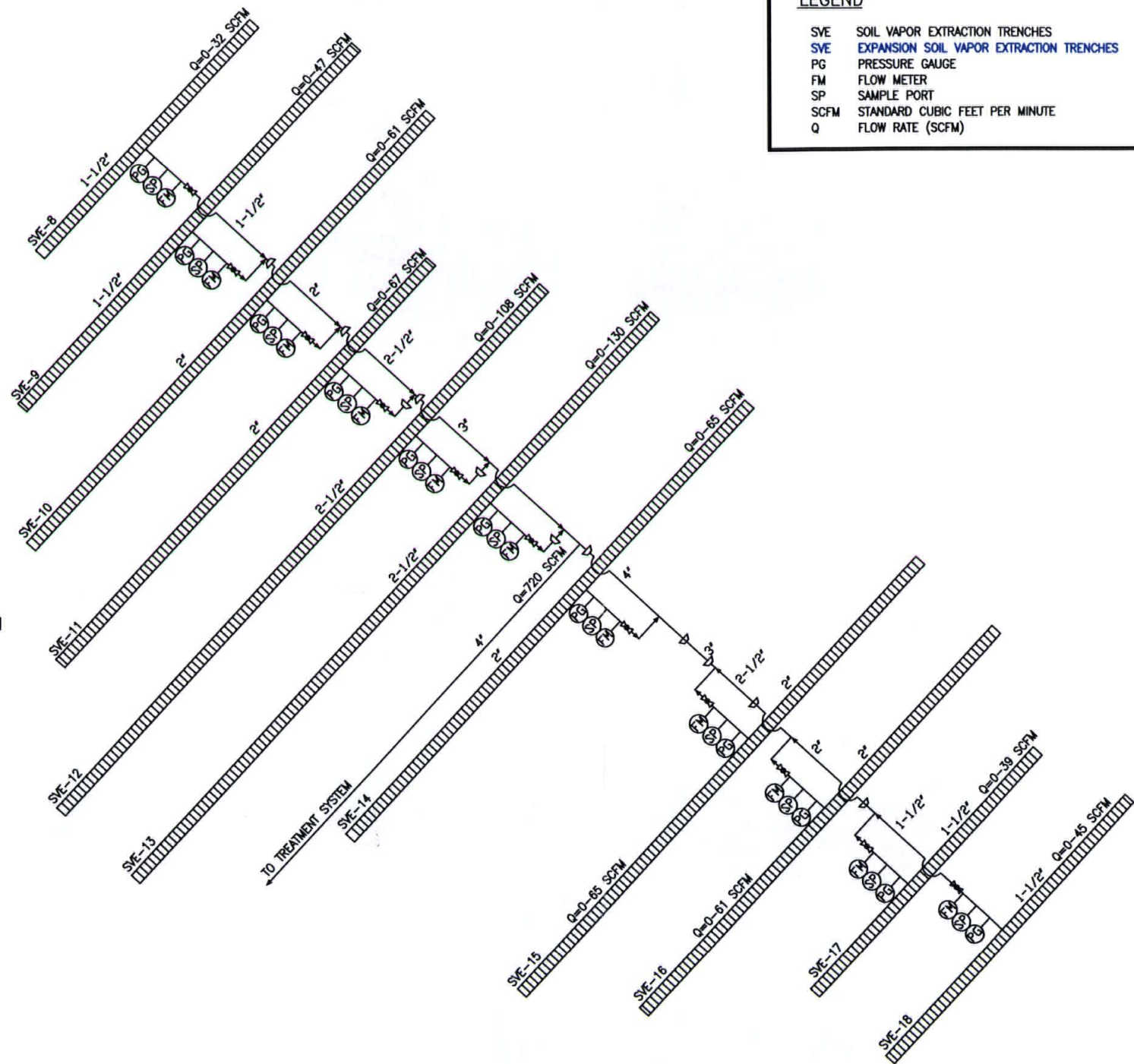
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| PROJECT MGR CEM | DESIGNED BY BT | DRAWN BY BT | CHECKED BY CEM | SCALE NO SCALE | DATE 28 JAN 99 | PROJECT NO 29600.35 | FILE NO FIG 2-7 |
|--------------------|-------------------|----------------|-------------------|-------------------|-------------------|------------------------|--------------------|

LEGEND

| | |
|------|--|
| SVE | SOIL VAPOR EXTRACTION TRENCHES |
| SV | EXPANSION SOIL VAPOR EXTRACTION TRENCHES |
| PG | PRESSURE GAUGE |
| FM | FLOW METER |
| SP | SAMPLE PORT |
| SCFM | STANDARD CUBIC FEET PER MINUTE |
| Q | FLOW RATE (SCFM) |



WESTERN SVE SYSTEM LAYOUT
NOT TO SCALE



EASTERN SVE SYSTEM LAYOUT
NOT TO SCALE

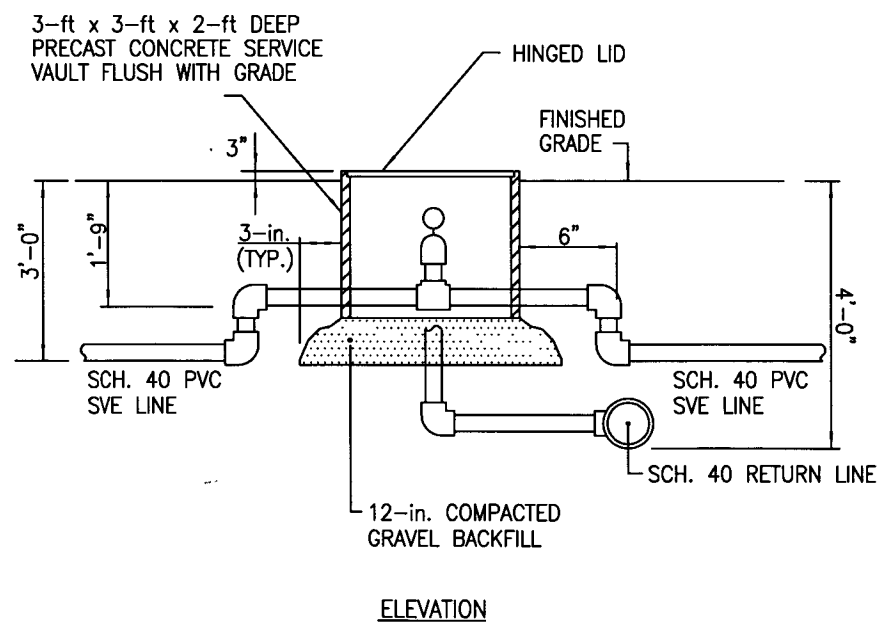
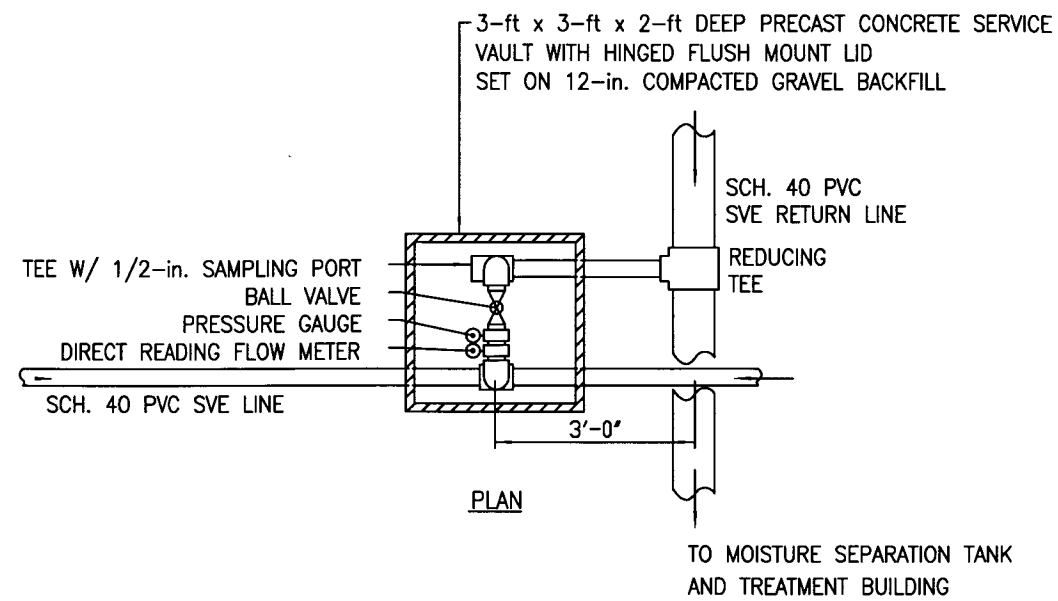
ADAPTED FROM PRELIMINARY OPERATIONS
AND MAINTENANCE PLAN (OHM 1995)



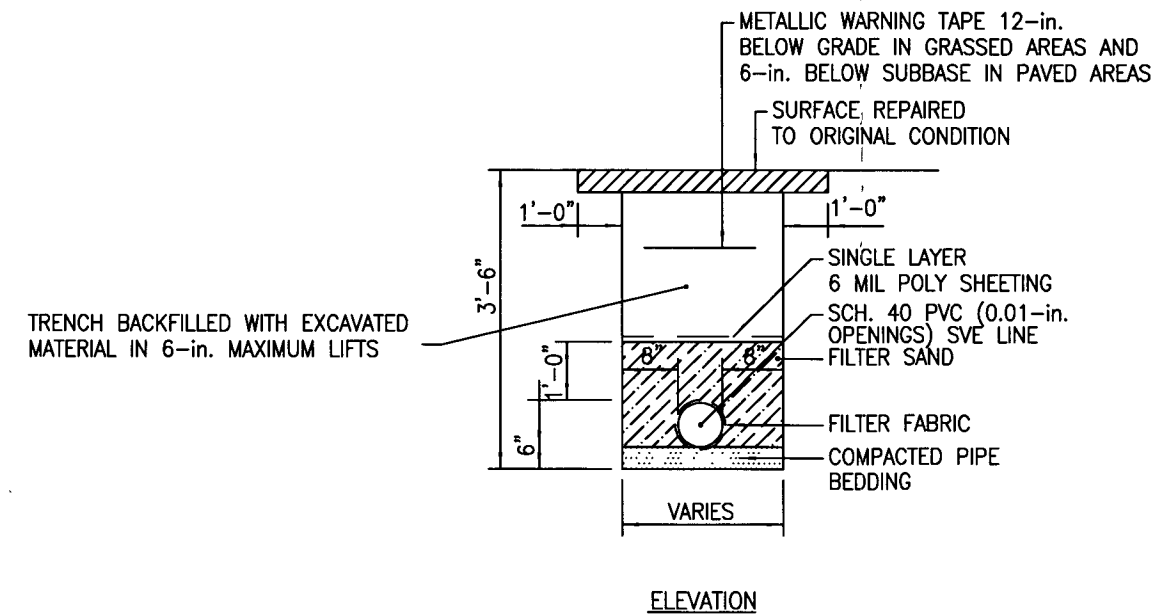
OLD NAVY FUEL FARM
NAVAL AIR STATION
BRUNSWICK, MAINE

FIGURE 2-8
SOIL VAPOR EXTRACTION WELL AND
TRENCH INSTRUMENTATION DIAGRAM

| | | | | |
|--------------------|---------------------|--------------------|-------------------------|----------------------|
| DESIGNED BY CEM | DRAWN BY SAP | DATE 5 JAN 1999 | PROJECT NO. 29600.35 | FILE NAME FIG 2-8 |
| CHECKED BY DSS | PROJECT MGR. JAC | SCALE NO SCALE | DRAWING NO. - | FIGURE 2-8 |

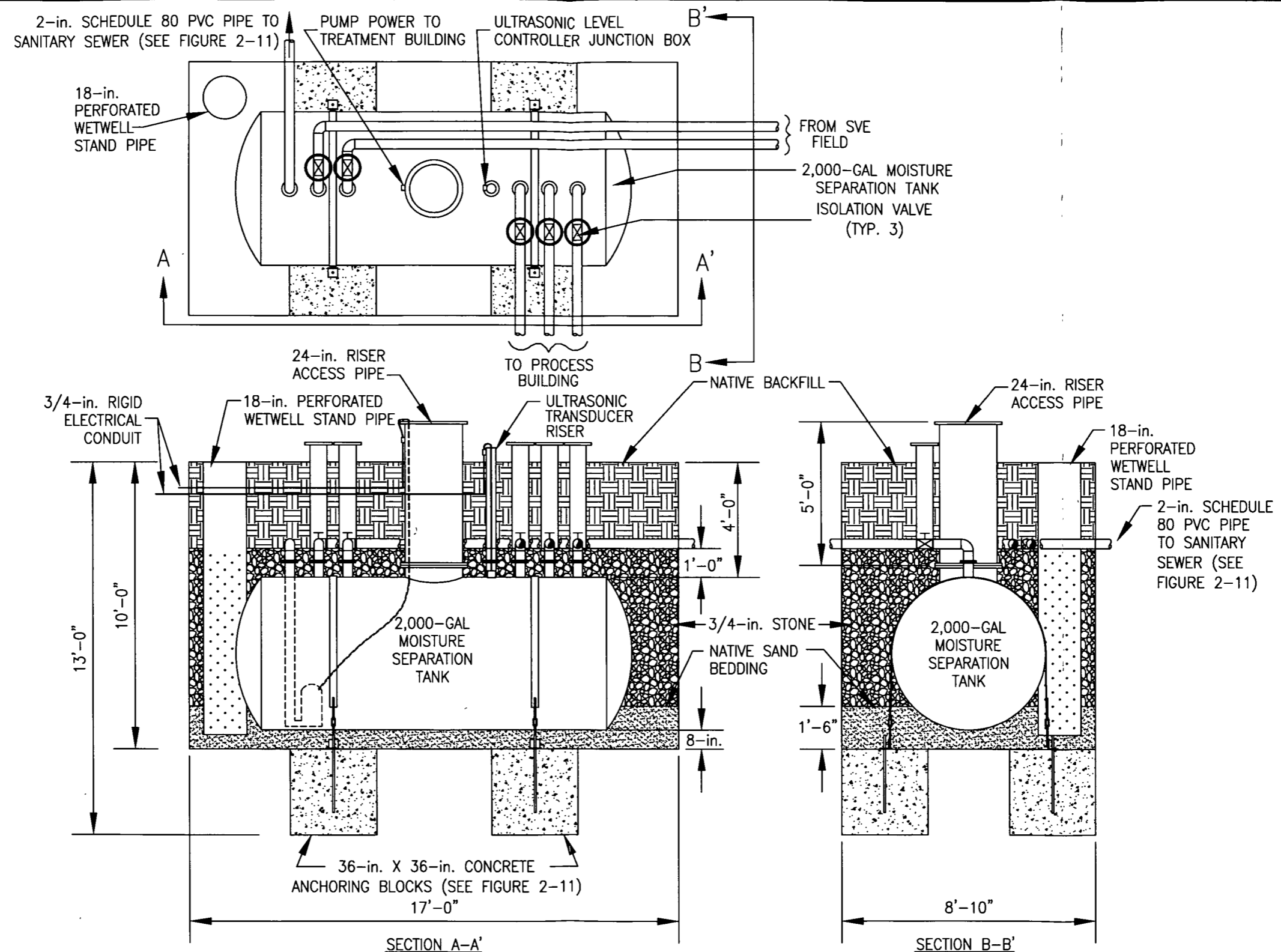


SOIL VAPOR EXTRACTION RETURN LINE SERVICE VAULT



TYPICAL SOIL VAPOR EXTRACTION LINE TRENCH DETAILS

ADAPTED FROM PRELIMINARY OPERATIONS
AND MAINTENANCE PLAN (OHM 1995)



2,000 GAL MOISTURE SEPARATION TANK DETAIL

SCALE: 1/4"=1'-0"

**TABLE 2-1 AIR SPARGING SYSTEM OPERATIONAL INSPECTION
AND START SEQUENCE CHECKLIST
OLD NAVY FUEL FARM
NAVAL AIR STATION, BRUNSWICK, MAINE**

PRE-START OPERATIONAL INSPECTION

Air Sparging Process Equipment:

- Confirm accessibility and overall condition of air sparging service vaults in the field
- Electrical service confirmed; circuit breakers and control panel energized
- Confirm no existing control faults; clear or reset as required
- Confirm operation and position of air sparging hand-off-auto switch on control panel
- Inspect piping, valves, and fittings for tightness
- Confirm air sparging blower lubrication is adequate (Appendix A)
- Confirm air sparging blower drive belt tension and alignment; confirm proper installation of belt guard
- Open diversion valve (Figure 2-4) (to atmosphere) for unloaded start of air sparging blower

Air Sparging System Start Sequence:

- Set (AAS) hand-off-auto switch to "Auto" (control panel) (Figure 2-7)
- Partially close diversion valve (Figure 2-4) to divert air to air sparging well heads; do not exceed pressure relief limit (15 psi)
- Confirm that pressure and flow are established at appropriate air sparging well head assemblies
- Normalize air sparging injection rate per Section 2.1.5
- Record operational start time and mechanical/operational parameters in site log

**TABLE 2-2 AIR SPARGING COMPRESSOR TROUBLESHOOTING
OLD NAVY FUEL FARM
NAVAL AIR STATION, BRUNSWICK, MAINE**

| Symptoms | Probable Cause | Remedies ^(a) |
|--|---|---|
| Loss of oil | Gear housing not tightened properly | Tighten gear housing bolts |
| | Lip seal failure | Disassemble and replace lip seal |
| | Insufficient sealant | Remove gear housing and replace sealant (see Disassembly and Inspection Section) |
| Excessive bearing or gear wear | Improper lubrication | Correct oil level; replace dirty oil (see Lubrication Interval) (Table 2-4) |
| | Excessive belt tension | Check belt manufacturer's specifications for tension and adjust accordingly |
| | Coupling misalignment | Check carefully; realign if necessary |
| Lack of air volume | Slipping belts | Check belt manufacturer's specifications for tension and adjustment |
| | Worn lobe clearances | Check for proper clearances (see Specification Sheet "Assembly Clearances") |
| | Speed too low | Increase blower speed within limits |
| | Obstruction in piping | Check system to assure an open flow path |
| Knocking | Unit out of time | Re-time |
| | Distortion due to improper mounting or pipe strains | Check mounting alignment and relieve pipe strains |
| | Excessive pressure differential | Reduce to manufacturer's recommended pressure; examine relief valve; reset if necessary |
| | Worn gears | Replace timing gears (see Disassembly and Inspection Section) |
| Excessive blower temperature | Too much or too little oil in gear reservoir | Check oil level (see Lubrication Section) |
| | Too low operating speed | Increase blower speed within limits |
| | Clogged filter or silencer | Remove cause of obstruction |
| | Excessive pressure differential | Reduce pressure differential across the blower |
| | Elevated inlet temperature | Reduce inlet temperature |
| | Worn lobe clearances | Check for proper clearances (see Specification Sheet "Assembly Clearances") |
| (a) Unless otherwise noted, specification, inspection, lubrication, and disassembly guidance are provided in Appendix A, Blower Manual (45 Series, Dura-Flow, Gardner-Denver units). | | |

| Symptoms | Probable Cause | Remedies ^(a) |
|--|--|---|
| Rotor end or tip drag | Insufficient assembled clearances | Correct clearances (see Specification Sheet "Assembly Clearances") |
| | Case or frame distortion | Check mounting and pipe strain |
| | Excessive operating pressure | Reduce pressure differential |
| Vibration | Excessive operating temperature | Reduce pressure differential or reduce inlet temperature |
| | Belt or coupling misalignment | Check carefully; realign if necessary |
| | Lobes rubbing | Check cylinder for hot spots and then check for lobe contacts at these points; correct clearances (see Specification Sheet "Assembly Clearances") |
| | Worn bearings/gears | Check condition of gears and bearings; replace if necessary |
| | Unbalanced or rubbing lobes | Possible buildup on casing or lobes, or inside lobes; remove buildup and restore clearances |
| | Driver or blower loose | Check mounting and tighten if necessary |
| | Accumulation of entrained material on impeller and housing | Remove cover; clean impeller and housing |
| High current draw/ thermal overload | Damaged or collapsed bearings | Replace bearings |
| | Blower operating above rated pressure/vacuum | Reduce operating point pressure/vacuum (bleed air, recirculate gas) |
| | Low line voltage | Turn off blower until correct voltage/amperage is restored |
| NOTE: If there is suspicion that particulate material has entered the soil vapor extraction blower due to filter failure or other cause, it is recommended that the impeller covers be removed, and cleaning/inspection of the impeller, housing, and related equipment be accomplished. Excessive particulate contamination in the impeller housing may cause impeller imbalance leading to premature bearing wear. | | |

**TABLE 2-3 AIR SPARGING SYSTEM FLOW RATES
OLD NAVY FUEL FARM
NAVAL AIR STATION, BRUNSWICK, MAINE**

| Air Sparge Lines | Flow Gauge Values SCFM) | AAS Well Vaults |
|--|----------------------------|--------------------|
| ASL-1 | 12 | ASW-1 to ASW-3 |
| ASL-2 | 36 | ASW-4 to ASW-12 |
| ASL-3 | 44 | ASW-13 to ASW-23 |
| ASL-4 | 48 | ASW-24 to ASW-35 |
| ASL-5 | 48 | ASW-36 to ASW-47 |
| ASL-6 | 48 | ASW-48 to ASW-59 |
| ASL-7 | 56 | ASW-60 to ASW-73 |
| ASL-8 | 4 | ASW-74 to ASW-75 |
| ASL-9 | 8 | ASW-76 to ASW-79 |
| ASL-10 | 12 | ASW-80 to ASW-85 |
| ASL-11 | 14 | ASW-86 to ASW-92 |
| ASL-12 | 16 | ASW-93 to ASW-100 |
| ASL-13 | 26 | ASW-110 to ASW-113 |
| ASL-14 | 22 | ASW-114 to ASW-124 |
| ASL-15 | 20 | ASW-125 to ASW-134 |
| ASL-16 | 20 | ASW-135 to ASW-144 |
| ASL-17 | 20 | ASW-145 to ASW-154 |
| ASL-18 | 18 | ASW-155 to ASW-163 |
| ASL-19 | 12 | ASW-164 to ASW-166 |
| ASL-20 | 12 | ASW-167 to ASW-169 |
| NOTE: scfm = Standard cubic feet per minute. ASL = Air sparge line. ASW = Air sparge well. | | |

**TABLE 2-4 AIR SPARGING SYSTEM MAINTENANCE
OLD NAVY FUEL FARM NAVAL AIR STATION, BRUNSWICK, MAINE**

| Item | Frequency | Action |
|---|--|--|
| Oil lubrication | First 100 hours; each additional 1,000 hours | Review gear oil per Appendix A |
| Check/maintain oil level | Bi-Weekly | Add as necessary |
| Check for noise/vibration (see Table 2-2) | Bi-Weekly | Isolate source and correct |
| Check relief valve operation | Monthly | Adjust/replace as required; see note |
| Inspect entire system for leaks | Monthly | Refit/tighten/replace components as necessary |
| Check drive belt tension and alignment | Quarterly | Realign/adjust tension/replace as necessary |
| Inspect air filters | Quarterly | Clean/replace as required |
| Valves | Periodically | Confirm operation, repair, or adjust to ensure proper and safe operation |
| Air intakes | Quarterly | Check for blockage; clean with compressed air; replace if excessively restricted |
| Pressure gauges | Annually | Inspect stem for cleanliness; compare to known standard gauge |
| NOTE: To check relief valve, close dilution valve until relief valve discharges. Check pressure to ensure blowoff occurs at 15 psi. | | |

TABLE 2-5 SOIL VAPOR EXTRACTION SYSTEM OPERATIONAL INSPECTION
AND START SEQUENCE CHECKLIST
OLD NAVY FUEL FARM, NAVAL AIR STATION, BRUNSWICK, MAINE

PRE-START OPERATIONAL INSPECTION**SVE Process Equipment:**

- Electrical service confirmed; circuit breakers and control panel energized
- Confirm no existing control faults; clear or reset as required
- Confirm moisture separation tank empty
- Confirm operation and position of SVE hand-off-auto switch on control panel
- Adjust SVE influent valving; open valves on SVE risers selected for treatment
- Confirm valve settings for remaining SVE process piping (granular activated carbon routing, dilution air)
- Inspect piping, valves, and fittings for tightness
- **Test atmosphere (total volatile hydrocarbons in ppm) in treatment building and in individual SVE risers**
- Set SVE hand-off-auto switch to "hand;" jog SVE blower motor
- Confirm no anomalous SVE blower system noise or vibration

SVE System Start Sequence:

- Confirm all valve settings
- Set (SVE) hand-off-auto switch to "auto" (control panel)
- Confirm that vacuum/flow is established at appropriate SVE manifold risers
- Confirm vacuum at appropriate SVE risers in the field
- Record operational start time, and mechanical/operational parameters in site log

**TABLE 2-6 SOIL VAPOR EXTRACTION SYSTEM TROUBLESHOOTING
OLD NAVY FUEL FARM
NAVAL AIR STATION, BRUNSWICK, MAINE**

| Malfunction ^(a) | Possible Causes | Solutions |
|---|--|--|
| Excessive noise/vibration | Accumulation of entrained material on impeller and housing | Remove cover; clean impeller and housing |
| | Worn bearings | Replace bearings per specifications |
| | Impeller interference (impeller hits) due to overheating, which causes metal creep | Reduce operating point; replace impeller and housing if badly scored |
| High current draw/ thermal overload | Damaged or collapsed bearings | Replace bearings |
| | Blower operating above rated pressure/vacuum | Reduce operating point pressure/vacuum (bleed air, recirculate gas) |
| | Low line voltage, brown out | Turn off blower until correct voltage/amperage is restored |
| Excessive heat build-up | Same as above section | Same as above section |
| CARBON ADSORPTION SYSTEM | | |
| High pressure | Carbon plugging due to particulate carryover from upstream unit | Changeout carbon media |
| Premature volatile organic compound breakthrough | Inlet vapor temperature too high; flow channeling due to uneven flow or pressure | |
| Water accumulation | Malfunction of float sensors in moisture separators | Adjust or replace float sensors |
| <p>(a) If there is suspicion that particulate material has entered the soil vapor extraction blower due to filter failure or other cause, it is recommended that the impeller covers be removed, and cleaning/inspection of the impeller, housing, and related equipment be accomplished. Excessive particulate contamination in the impeller housing may cause impeller imbalance leading to premature bearing wear.</p> | | |

**TABLE 2-7 SOIL VAPOR EXTRACTION SYSTEM FLOW RATES
OLD NAVY FUEL FARM
NAVAL AIR STATION, BRUNSWICK, MAINE**

| SVE Vaults | Flow Gauge Values (scfm) |
|---|--------------------------|
| SVE-1 | 0 – 123 |
| SVE-2 | 0 – 163 |
| SVE-3 | 0 – 174 |
| SVE-4 | 0 – 206 |
| SVE-5 | 0 – 184 |
| SVE-6 | 0 – 159 |
| SVE-7 | 0 – 159 |
| SVE-8 | 0 – 32 |
| SVE-9 | 0 – 47 |
| SVE-10 | 0 – 61 |
| SVE-11 | 0 – 67 |
| SVE-12 | 0 – 108 |
| SVE-13 | 0 – 130 |
| SVE-14 | 0 – 65 |
| SVE-15 | 0 – 65 |
| SVE-16 | 0 – 61 |
| SVE-17 | 0 – 39 |
| SVE-18 | 0 – 45 |
| SVE-19 | 0 – 132 |
| SVE-20 | 0 – 100 |
| NOTE: scfm = Standard cubic feet per minute. SVE = Soil vapor extraction line. | |

**TABLE 2-8 SOIL VAPOR EXTRACTION SYSTEM MAINTENANCE
OLD NAVY FUEL FARM NAVAL AIR STATION, BRUNSWICK, MAINE**

| Item | Frequency | Action |
|---|--|---|
| Valves | Periodically | Confirm operation, repair, or adjust to ensure proper and safe operation |
| Air intakes | Quarterly | Check for blockage; clean with compressed air; replace if excessively restricted |
| Oil lubrication | First 100 hours; each additional 1,000 hours | Review gear oil per Appendix A |
| Check/maintain oil level | Bi-Weekly | Add as necessary |
| Check for noise/vibration (see Table 2-6) | Bi-Weekly | Isolate source and correct |
| Check relief valve operation | Monthly | Adjust/replace as required. |
| Inspect entire system for leaks | Monthly | Refit/tighten/replace components as necessary |
| Check drive belt tension and alignment | Quarterly | Realign/adjust tension/replace as necessary |
| Inspect air filters | Quarterly | Clean/replace as required |
| Flow sensors (pitot tubes) | As needed | Confirm proper positioning; check for particulate contamination (refer to Appendix A for calibration data) |
| Temperature gauges | Annually | Inspect stem for accumulation of foreign material (insulating layer); clean as necessary (no serviceable parts or adjustments) (refer to Appendix A for specifications/model numbers) |
| Vacuum gauges | Annually | Inspect stem for cleanliness; compare to known standard gauge |

3. CONTROL ALARM SYSTEMS AND SUPPORT SERVICES

3.1 GENERAL DESCRIPTION

SVE/AAS alarm systems at the treatment building include local control fault indications. Support services include electrical utilities and security. The control fault system provides automatic shutdown of the Old Navy Fuel Farm treatment plant systems to prevent damage. The system is remotely monitored by the Building 50 SCADA system. The eight run and six alarm indicators are monitored locally by a Modicon PLC. The PLC does not perform control functions for these alarm and run conditions. The PLC monitors the conditions and transmits these conditions to the Building 50 SCADA system. The PLC also accepts alarm and run status conditions for the liquid level in the MST, the transfer pump, and the high level alarm at the sanitary sewer discharge point. The PLC interprets these data and performs control and alarm functions. These alarm and run status conditions are then transmitted by radio telemetry to Building 50 where they are incorporated into the SCADA system. The alarm and run status can be viewed at Building 50. In the event of an alarm condition, the SCADA system will log the alarm condition and alert the operator to this alarm.

3.2 AIR SPARGING SYSTEM CONTROL FAULTS

Unless a system-wide failure occurs, control faults affect only shutdown of the AAS system; other remediation equipment may remain operational. AAS control faults and causes are provided below:

- **High Blower Temperature**—The sparge compressor motor is thermally protected. Upon activation of the thermal protection, a control fault is initiated resulting in shut down of the AAS system to prevent damage to the blower. High compressor temperature may be caused by restricted air flow (i.e., incorrect control valve settings or clogged pipes) or by internal compressor problems (i.e., low gear oil, bearing failure, etc.).

Figure 2-7 presents the layout of the AAS control system panel. Figure 1-4 presents a process flow and instrumentation diagram.

3.3 ELECTRICAL SYSTEM

Electrical power, supplied by Central Maine Power of Maine, is comprised of 480-volt/three-phase and 120/240-volt/single-phase power supplies. The 480-volt system powers the air compressors (C-1A, C-1B, and C-2), SVE blowers (V1-A, V1-B, and V2), radiators, water pump, exhaust fan, unit heater, and drycore transformer. The 120/240 volt system (Panel A) powers the interior and exterior lighting of the metal building.

Electric power for the treatment building and associated remediation system equipment is provided by a tap into an existing 35-kv overhead power line located southwest of the treatment building. The 35-kv power is conveyed through a 4-in. diameter underground conduit from the pole to the transformer pad. Three 75 kilovolt-ampere (kva) transformers reduce the voltage of the incoming power to 480 volts. A 3-in. diameter underground conduit directs power from the transformer pad through a meter and main circuit breaker, and into a 480-volt power panel located along the west wall of the treatment building. The wall mounted, 15-kva, drycore transformer reduces the power in the main panel from 480 volts to 120/240-volt/single-phase to power Panel A, and is located in the west end of the treatment building.

NAS Brunswick Public Works, Security, or emergency response personnel should coordinate with the EA Project Manager or designated representative (Section 5.4.1) prior to initiating service or maintenance of electrical fixtures or components within the Old Navy Fuel Farm treatment building. Evaluation and service by a licensed electrician, or by the equipment manufacturer, may be required.

3.4 SECURITY

Security for the treatment building is accomplished through lock/key control. Locks are located on the treatment building doors and the monitoring well riser caps. Keys are maintained in Building 50 (Ground-Water Extraction Treatment Plant control room) located on Old Gurnet Road at NAS Brunswick. Keys are also available through the NAS Brunswick Department of Public Works.

4. AIR SPARGING SYSTEM PERFORMANCE MONITORING AND SAMPLING

Operations and maintenance activities are routinely performed at the Old Navy Fuel Farm treatment plant to provide data for the evaluation of treatment facility performance and the overall effectiveness of the treatment processes. System performance monitoring includes measurements at well points to assess total volatile hydrocarbons, methane, oxygen, and carbon dioxide concentrations. Monitoring also includes gauging of well points and monitoring wells for ground-water elevation; presence and thickness of light, non-aqueous phase liquid; and measurement of water quality indicator parameters. System maintenance checks, as described in Chapter 2, are also included as part of the routine system performance monitoring.

4.1 OPERATIONS AND MAINTENANCE SCHEDULE AND DATA RECORDS

Operations and maintenance activities are performed twice per month. Well points are gauged and air quality is monitored once per month. Wells are gauged and water quality indicator parameters are measured twice per month. A site entry logbook is maintained at the treatment building; all work accomplished is logged in with an accompanying signature. Data collected for each operation/maintenance event are recorded on project-specific data sheets (Appendix B).

4.2 AIR SPARGING SYSTEM PERFORMANCE MONITORING

AAS system performance monitoring includes air quality measurements of total volatile hydrocarbons, methane, and carbon dioxide at 21 well points. AAS system performance measurements are recorded on the Field Record of Air Sparging Well Point Monitoring Data Sheet (Appendix B).

4.3 SOIL VAPOR EXTRACTION SYSTEM PERFORMANCE MONITORING

The SVE system requires samples to be collected at SVE intake and emission locations. Total volatile hydrocarbon concentrations are measured using a photoionization detector. Total volatile hydrocarbon screening at the SVE/AAS is conducted using a Foxboro TVA-1000B photoionization/flame ionization detector, calibrated with isobutylene gas standard. Soil vapor is collected in a 1-L Tedlar sample bag as indicated below.

Total volatile hydrocarbon concentrations are measured in parts per million and recorded on the Field Record of SVE System Operations Data Sheet (Appendix B). Ancillary equipment used to collect the sample includes flexible tubing and fittings. Sample ports installed in the SVE discharge piping allow for sample collection. To collect a sample, perform the tasks listed below:

- Connect the flexible tubing to the sample port. Open the valve on the sample port and purge the tubing of ambient air.

- Once sample tubing is purged of ambient air, connect the Tedlar bag to the tubing and turn the 3-way sample inlet valve such that the SVE flow is directed into the sample bag. Once sample bag is full, close valve on sample bag and the sample port. Disconnect the tubing from the sample port.
- Measure total VOC concentration by connect the tubing to the tip of PID/FID (ensure that the sample bag inlet valve is open). Record highest total volatile hydrocarbon concentration on data sheet.

4.4 GROUND-WATER AND AIR SPARGING WELL MONITORING

The 11 ground-water monitoring wells and 21 well points at the Old Navy Fuel Farm (Figure 1-4) are monitored bi-monthly for ground-water elevation; presence and thickness of light, non-aqueous phase liquid; and for selected water quality indicator parameters including temperature, dissolved oxygen, redox, pH, and conductivity. An oil/water interface probe (Solinst Model 121) is used to measure ground-water elevation and presence and thickness of light, non-aqueous phase liquid. Measurement of ground-water elevation and light, non-aqueous phase liquid elevation and thickness are recorded to the nearest 0.01 ft and are recorded on the Field Record of Well Gauging Data Sheet (Appendix B). A multi-parameter water quality meter (Yellow Springs Instrument Model 600XL or Hydrolab Scout[®]2 with H20[®]G multiprobe) is used to measure water quality indicator parameters *in situ*. Water quality indicator parameters are used in part to determine the influence of the AAS system on site ground water and are recorded on the Field Record of Water Quality Parameter Analysis Data Sheet (Appendix B).

4.5 SOIL VAPOR EXTRACTION SYSTEM PROCESS WATER SAMPLING

Process water samples are collected monthly from the sampling port in the metering vault located northwest of the MST. The data collected from the monthly grab samples include the effluent flow rate and laboratory analyses necessary to determine the quality of water discharged to the Brunswick Sewer District. The samples will be analyzed for benzene, toluene, ethylbenzene, and total xylenes; total petroleum hydrocarbons—gasoline range organics; and total petroleum hydrocarbons—diesel range organics using the following methods: U.S. Environmental Protection Agency 602, Maine Department of Human Services—Health and Environmental Testing Laboratory Method 4.2.17, and Maine Department of Human Services—Health and Environmental Testing Laboratory Method 4.2.25, respectively. Flow and water quality data from monitoring of collection tank effluent, as well as monitoring and sampling parameters, will be included in the existing monthly ground-water extraction and treatment system reports to Brunswick Sewer District.

5. EMERGENCY RESPONSE PLAN

This chapter establishes procedures to be observed in the event of onsite emergency or breach of security that poses a potential threat to the occupational safety and health of employees or loss of property. This chapter is intended as a supplement to EA's comprehensive Basewide Safety, Health, and Emergency Response Plan (EA 1997). This chapter provides a summary of emergency recognition/notification and response procedures for various emergency/alarm scenarios (Sections 5.1 through 5.3). Roles and responsibilities of key project personnel associated with emergency response are listed in Section 5.4.

The Project Manager provides this Operations and Maintenance Manual and the Basewide Plan available for inspection by all field personnel. Prior to the initiation of work, operational personnel must become familiar with this chapter and oriented to the location of fire/emergency equipment, assembly locations, telephones, and medical emergency facilities. Technical support, emergency telephone contact numbers, and directions to the nearest hospital are provided in Appendix C.

5.1 EMERGENCY RECOGNITION/EMERGENCY RESPONSE AND NOTIFICATION

Project personnel recognizing existing or potential uncontrollable emergency conditions such as fire, explosion, medical emergency, electrical discharge, mechanical equipment accident, overexposure of personnel to contaminants, or other dangerous conditions must evaluate the magnitude of the emergency, initiate the NAS Brunswick emergency response system, and inform the Site Leader or Site Safety and Health Officer.

5.2 ONSITE RESPONSE

Initial emergency response must include an evaluation of the magnitude or potential magnitude of the emergency, and a determination of extent of personal injury. If no threat to the safety of onsite responders exists, localized emergency control measures, including first-aid/CPR treatment, localized fire control, de-energizing of electrical panels, and/or lockout of energy sources, may be undertaken to the extent that site personnel are trained and able to safely respond. During initial emergency response, the leader maintains local site control. Offsite notification is made as soon as possible.

First aid/emergency equipment is available at the following site locations:

- First aid kit: Old Navy Fuel Farm treatment building and site vehicle
- Eye wash: Old Navy Fuel Farm treatment building and site vehicle
- Fire extinguisher: Old Navy Fuel Farm treatment building and site vehicle.

5.3 NOTIFICATION

Uncontrollable onsite emergencies will ultimately require response by offsite emergency personnel. In such cases, primary consideration must be given to preserving safety, health, and property. A determination must be made by the Site Leader to contact emergency services personnel directly from the site, or to defer to the NAS Brunswick Emergency Response Coordinator for this notification. Regardless of the determination, the Project Manager and the Program Safety and Health Officer are advised as soon as possible. The Site Leader is advised that information is provided to emergency responders only on an emergency-specific, "need to know" basis. Following Emergency Response Coordinator notification, the Site Leader continues to maintain local site control as directed by the NAS Brunswick Emergency Response Coordinator emergency services personnel. The NAS Brunswick Emergency Response Coordinator may defer the direction of site activities to the Project Manager. Once notified of a site emergency, the Project Manager then communicates with the designated NAS Brunswick representative, the Program Safety and Health Officer, or the Site Safety and Health Officer to evaluate hazards.

5.3.1 Reporting Emergency Incidents

Following an emergency, accident, or other incident involving site personnel, the Site Leader must complete an Accident Investigation Report (EA 1993) and submit it to the Project Manager, Program Safety and Health Officer, NAS Brunswick Emergency Response Coordinator and Northern Division Remedial Project Manager within 24 hours for the following types of incidents:

- Job-related injuries and illnesses
- Accidents resulting in loss or damage to property
- Accidents involving vehicles whether or not they result in damage to property or personnel
- Accidents in which there may have been no injury or property damage, but which have a high probability of recurring with at least a moderate risk to personnel or property.

Following an emergency, accident, or incident involving site personnel, equipment, or facilities, the Project Manager must report the following information to EA project personnel and NAS Brunswick Emergency Response Coordinator Accident Investigation personnel:

1. Name and location of person initially reporting
2. Location of accident/incident
3. Name and affiliation of injured party
4. Description of injuries, fire, spill, or explosion

5. Status of medical aid and/or other emergency control efforts
6. Details of any chemicals involved
7. Summary of accident, including suspected cause and time it occurred
8. Temporary control measures taken to minimize further risk.

This information is not to be released under any circumstances to parties other than those listed in this section and emergency response team members.

An additional responsibility of the Project Manager is the reporting of any accident that results in a fatality or the hospitalization of three or more employees. Such accidents must be reported within 8 hours to the U.S. Department of Labor.

5.4 PROJECT PERSONNEL

5.4.1 Key Personnel

The following lists the key personnel for this project:

| | | |
|--|----------------------|--------------|
| Program Manager | Charles Flynn | 410-584-7000 |
| Program Safety and Health Officer | Kris Hoiem, CIH | 410-771-4950 |
| Project Manager | John Carnright | 914-565-8100 |
| Project Engineer | Charles McLeod, P.E. | 914-565-8100 |
| Project Supervisor | Bartt Booz | 207-798-5977 |
| Site Leader/Site Safety and Health Officer | Suzanne Chase | 207-798-5977 |
| Treatment Plant Operator | Michael Chase | 207-798-5977 |

5.4.2 Responsibilities

The chain-of-command for safety and health-related issues and emergency response for operations at the Old Navy Fuel Farm treatment facility is detailed below. All levels of EA management assume responsibility for observing the chain-of-command and appropriately involving and reporting to NAS Brunswick representatives.

Program Manager

Mr. Charles Flynn serves as the Program Manager; his responsibilities include:

- Assisting the Project Manager in procuring staff assignments.
- Ensuring field team responsiveness to the Project Manager and the Program Safety and Health Officer.

Program Safety and Health Officer

Mr. Kris Hoiem, CIH, serves as the Program Safety and Health Officer; his responsibilities include:

- Providing authorization, if warranted, for modification/upgrade in personal protective equipment requirements based on field conditions.
- Providing final review of all safety and health monitoring records and personal protective equipment changes to ensure compliance with the provisions of the site Safety and Health Plan.
- Providing accident reporting format and requirements. Review completed accident reports, including proposed corrective action.

Project Manager

Mr. John Carnright serves as the Project Manager; his responsibilities include:

- Assuring compliance with the site Safety and Health Plan.
- Coordinating with NAS Brunswick representatives.
- Staff assignment of Site Leader and Site Safety and Health Officer positions, assuring that onsite staff enforce the provisions of the approved site Safety and Health Plan.
- Assuring adequate resource availability for safety and health protection.
- Coordinating site occupational safety and health issues with the Program Safety and Health Officer.
- Initiating and/or response to internal and NAS Brunswick correspondence and communication, including incident report review and submittal to NAS Brunswick representatives.

Project Engineer

Mr. Charles E. McLeod, Jr., P.E., serves as the Project Engineer; his responsibilities include:

- Conducting engineering inspections of the site.
- Investigating and reporting engineering problems, as necessary.
- Acting on behalf of the Site Leader, as necessary.

Project Supervisor

Mr. Bartt Booz serves as the Project Supervisor; his responsibilities include:

- Modifying of site safety and health requirements or work plans.
- Evaluating onsite environmental monitoring results and reporting to the Project Manager.
- Delegating staff to respond to mechanical issues/alarms.
- Directing management of plant operator.

During any emergency, the Project Supervisor will be responsible for initiating and coordinating responses. In this situation, the Project Supervisor will:

- Work with the Site Safety and Health Officer to identify and evaluate hazards.
- Assume responsibility for evacuation of the work site as needed, and communicating with designated NAS Brunswick representative and offsite emergency responders.
- Delegate staff as required to respond to fire/security alarms.
- Determine if the abatement of hazardous conditions is sufficient prior to allowing resumption of work operations after an emergency.
- Consult with the Program Safety and Health Officer concerning key project safety and health concerns.
- Direct/approve modifications to emergency response/security plans for the Old Navy Fuel Farm treatment plant.
- Review project correspondence and communications associated with emergency/security incidents. Includes incident reports from Project Manager.
- Direct the continuation or interruption of site operations in response to a reported incident or accident at the site.

Site Leader/Site Safety and Health Officer

Ms. Suzanne Chase serves as the Site Safety and Health Officer; her responsibilities include:

- Implementing guidance within the provisions of the Site Safety and Health Plan.
- Providing initial safety and health briefing to site workers, subcontractors, and visitors.
- Evaluating reported hazardous conditions and recommending corrective actions. All confirmed occupational safety and health incidents, site hazards, or unsafe conditions/procedures, and the implemented corrective actions are coordinated with the Program Safety and Health Officer.
- Terminating work when imminent safety or health risks exist or as outlined in the Site Safety and Health Plan.
- Conducting necessary safety and health monitoring.
- Establishing and ensuring compliance with site control areas and procedures.
- Supervising decontamination activities to ensure adequate decontamination of personnel, tools, and equipment in accordance with the Site Safety and Health Plan.
- Supervision of the distribution, use, maintenance, and disposal of personal protective clothing and equipment in accordance with the Site Safety and Health Plan.

Treatment Plant Operator

Mr. Michael Chase serves as the Treatment Plant Operator; his responsibilities include:

- Responding to mechanical issues/alarms.
- Performing routine operations and maintenance.

REFERENCES

EA Engineering, Science, and Technology. 1993. Final Health and Safety Plan for Navy Exchange Service Station, Brunswick Naval Air Station, Brunswick, Maine. June.

EA. 1997. Basewide Safety, Health, and Emergency Response Plan, Naval Air Station, Brunswick, Maine.

EA. 1999. Old Navy Fuel Farm Engineering Evaluation Report, Naval Air Station, Brunswick, Maine. February.

O'Brien & Gere Engineers, Inc. 1990. Design and Installation of Underground Storage Tank Monitoring System, Naval Air Station Fuel Farm, Brunswick, Maine. Prepared for Department of the Navy, NAVFAC, Northern Division. April.

O'Brien & Gere Engineers, Inc. 1992. Remedial Investigation, Fuel Farm, Naval Air Station, Brunswick, Maine. Department of the Navy, NAVFAC, Northern Division. July.

OHM Remediation Services Corporation. 1995. Preliminary Operations and Maintenance Plan for the Air Sparging/Soil Vapor Extraction System, Fuel Farm Remediation. Brunswick Naval Air Station, Brunswick, Maine. 7 November.

Appendix A

Selected Unit Process Equipment Figures and Applicable Manufacturer Catalog Information

APPENDIX A

SELECTED UNIT PROCESS EQUIPMENT

1. Toshiba World Energy Motors
2. Gardner Denver® Duroflow® Blowers, Series 30, 45 and 70
3. Dwyer Magnehelic Differential Pressure Gage
4. Armor-Flo™ 3200 See-Flo® Meters

TOSHIBA

A Quality Product
for World Energy

INSTRUCTIONS:

Installation and Maintenance

Toshiba World Energy Motors
Polyphase motors

- Frames 143T through 507UZ
Dripproof
- Frames 143T through N587UZ
Totally-Enclosed Fan-Cooled
- Frames 143T through 447TZ
Explosion-Proof

STORAGE

- (1) Store motor in a clean, dry location and cover completely with plastic. (Leave opening for ventilation)
- (2) Motor must be thoroughly dry before applying power.
- (3) Every six months, give winding a megger test. A minimum of 10 megohms are recommended.
- (4) Also, every six months, rotate shaft and add grease as needed.

READ CAREFULLY BEFORE INSTALLING AND STARTING MOTOR

RECEIVING

- (1) Check nameplate data.
- (2) Check whether any damage has occurred during transportation. (Motors are normally shipped F.O.B. factory. Freight claims must be submitted by the consignee to the carrier.)
- (3) When supplied—Be sure to remove bearing lock plate before start-up.
- (4) Turn shaft by hand to check that it turns freely.

LOCATION

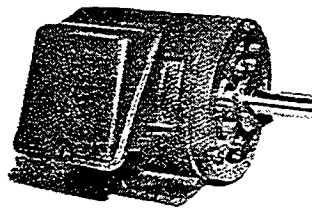
- (1) All motors should be located in an area where ventilation is not restricted and affects the operation of the motor.
- (2) Dripproof Motors are designed for installation in a well ventilated place where the atmosphere is reasonably free of dirt and moisture.
- (3) Totally enclosed motors may be installed where dirt, moisture (not running water) and corrosion are present, or in outdoor locations.
- (4) Explosion Proof motors are designed and built for hazardous duty.
Listed by U L for Class I, Group D; and Class II, Groups E, F and G. Also listed by C S A.

MOUNTING

- (1) Mount motor securely on a firm, flat base. All ball and roller bearing normal thrust motors may be mounted in any position.
- (2) Align motor accurately, using a flexible coupling if possible. For drive recommendations consult with drive or equipment manufacturer, or Toshiba. See additional information on pages 3 and 4.
- (3) V-belt Sheave Pitch Diameters should not be less than the following Table 1, values (NEMA recommended values).
- (4) Tighten belts only enough to prevent slippage. Belt speed should not exceed 5000 ft. per min.
- (5) Motors must not be subjected to vibration exceeding 0.5 G force.
(Motors should not be mounted to shaker screens)

POWER SUPPLY & CONNECTIONS

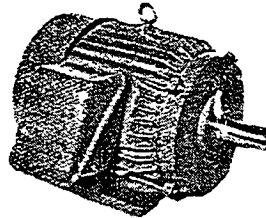
- (1) Nameplate voltage and frequency should agree with power supply. Motor will operate satisfactorily on line voltage within 10% of nameplate value; or frequency within 5%; combined variation not to exceed 10%. 230 Volt motors can be used on 208-volt network systems, but with slightly modified performance characteristics.
- (2) Dual voltage and single voltage motors can be connected for the desired voltage by following connection diagram shown on nameplate. Alternate starting connections are shown in the conduit box or connection diagrams on pages 5 and 6.
- (3) Explosion Proof motors have Temperature Limiting Devices in the motor enclosure to prevent excessive external surface temperature of the motor in accordance with U L standards. Terminals of thermal protectors (P1, P2) should be connected to the motor control equipment.
- (4) Wiring of motor and control, overload protection and grounding should be in accordance with National Electrical Code and local building codes.
- (5) Disconnect motor from power supply before opening conduit box or working on motor.
- (6) Every six months, give winding a megger test. A minimum of 10 megohms are recommended.



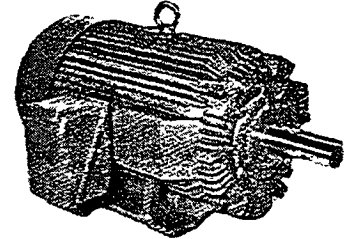
ODP Frames 143T-256T



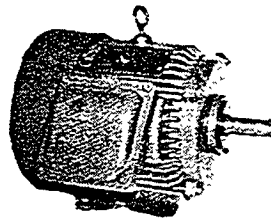
ODP Frames 404T-507UZ



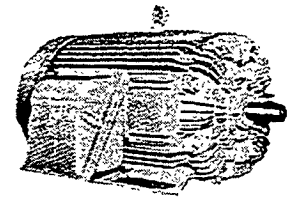
TEFC Frames 143T-256T



TEFC Frames 444T-N587UZ



XP Frames 143T-256T



XP Frames 404T-447TZ

Table 1. V-belt Sheave Pitch Diameters (MG1-14.42)

| Frame No. | Horsepower at Sync. Speed RPM | | | V-belt Sheave (Inches) | | | |
|-----------|-------------------------------|------|------|------------------------|-------------|-----------------------|--------------|
| | | | | Conventional | | Narrow | |
| | | | | A, B, C, D and E | | 3V, 5V and 8V | |
| | 3600 | 1800 | 1200 | Min. Pitch Diameter | *Max. Width | Min. Outside Diameter | **Max. Width |
| 143T | 1½ | 1 | ¾ | 2.2 | 4.250 | 2.2 | 2.250 |
| 145T | 2-3 | 1½-2 | 1 | 2.4 | 4.250 | 2.4 | 2.250 |
| 182T | 3 | 3 | 1½ | 2.4 | 5.250 | 2.4 | 2.750 |
| 182T | 5 | — | — | 2.6 | 5.250 | 2.4 | 2.750 |
| 184T | — | — | 2 | 2.4 | 5.250 | 2.4 | 2.750 |
| 184T | 5 | — | — | 2.6 | 5.250 | 2.4 | 2.750 |
| 184T | 7½ | 5 | — | 3.0 | 5.250 | 3.0 | 2.750 |
| 213T | 7½-10 | 7½ | 3 | 3.0 | 6.500 | 3.0 | 3.750 |
| 215T | 10 | — | 5 | 3.0 | 6.500 | 3.0 | 3.750 |
| 215T | 15 | 10 | — | 3.8 | 6.500 | 3.8 | 3.750 |
| 254T | 15 | — | 7½ | 3.8 | 7.750 | 3.8 | 4.000 |
| 254T | 20 | 15 | — | 4.4 | 7.750 | 4.4 | 4.000 |
| 256T | 20-25 | — | 10 | 4.4 | 7.750 | 4.4 | 4.000 |
| 256T | — | 20 | — | 4.6 | 7.750 | 4.4 | 4.000 |
| 284T | — | — | 15 | 4.6 | 9.000 | 4.4 | 4.250 |
| 284T | — | 25 | — | 5.0 | 9.000 | 4.4 | 4.250 |
| 286T | — | 30 | 20 | 5.4 | 9.000 | 5.2 | 4.250 |
| 324T | — | 40 | 25 | 6.0 | 10.250 | 6.0 | 5.250 |
| 326T | — | 50 | 30 | 6.8 | 10.250 | 6.8 | 5.250 |
| 364T | — | — | 40 | 6.8 | 11.500 | 6.8 | 5.250 |
| 364T | — | 60 | — | 7.4 | 11.500 | 7.4 | 5.250 |
| 365T | — | — | 50 | 8.2 | 11.500 | 8.2 | 5.500 |
| 365T | — | 75 | — | 9.0 | 11.500 | 8.6 | 5.500 |
| 404T | — | — | 60 | 9.0 | 14.250 | 8.0 | 7.250 |
| 404T | — | 100 | — | 10.0 | 14.250 | 8.6 | 7.250 |
| 405T | — | — | 75 | 10.0 | 14.250 | 10.0 | 7.250 |
| 405T | — | 100 | — | 10.0 | 14.250 | 8.6 | 7.250 |
| 405T | — | 125 | — | 11.5 | 14.250 | 10.5 | 7.250 |
| 444T | — | — | 100 | 11.0 | 16.750 | 10.0 | 8.500 |
| 444T | — | 125 | — | 11.0 | 16.750 | 9.5 | 8.500 |
| 444T | — | 150 | — | — | — | 10.5 | 8.500 |
| 445T | — | — | 125 | 12.5 | 16.750 | 12.0 | 8.500 |
| 445T | — | 150 | — | — | — | 10.5 | 8.500 |
| 445T | — | 200 | — | — | — | 13.2 | 8.500 |

*Max. sheave width = 2 (N-W) - ¼". **Max. sheave width = N-W.

Sheave ratios greater than 8:1 and center-to-center distance less than the diameter of the large sheave should be referred to the company.
Sheaves must be mounted close to the shaft shoulder.

Fig. 1 SHAFT EXTENSION LOADS DUE TO TRANSMISSION OF POWER

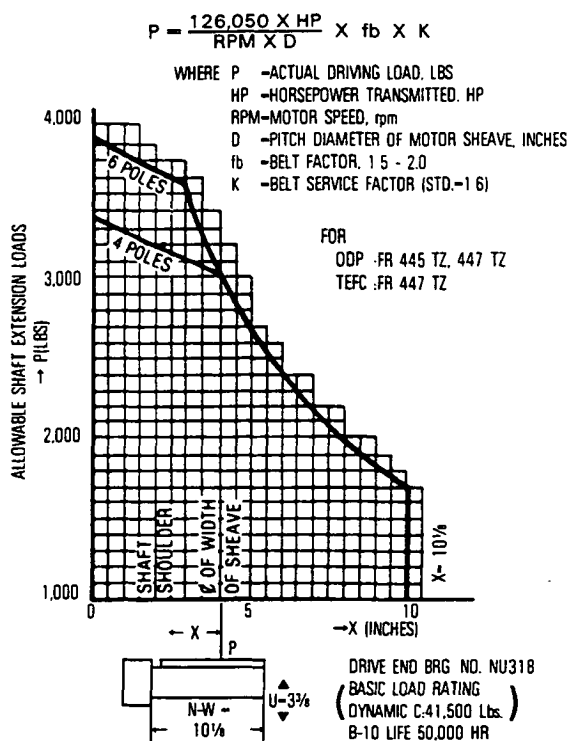
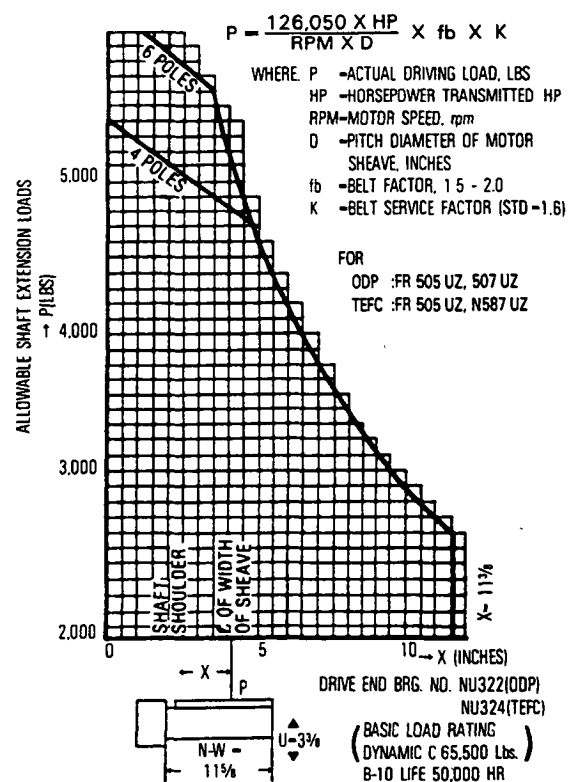


Fig. 2 SHAFT EXTENSION LOADS DUE TO TRANSMISSION OF POWER



ALIGNMENT PROCEDURES

MOTOR LEVELING & COUPLING ALIGNMENT

When the base has been adjusted, leveled, and grouted, the correct motor leveling and coupling alignment are obtained with the aid of shims between the motor and the base. To give the motor proper support, it is important that the base and shims extend under the motor.

RIGID COUPLING

Extreme care must be taken to obtain correct alignment when using rigid couplings. Circular concentric peripheral surfaces of the two coupling halves must indicate correct alignment within 0.0005 in. to 0.001 in. when the two coupling halves are rotated together. The separation between the faces of the two coupling halves must also be maintained within the same tolerance.

The alignment may be checked by utilizing a dial indicator as shown in Fig. 3 or with the aid of a straight-edge and thickness gauge or feelers as shown in Fig. 4.

The preferred method of checking alignment is with the dial indicator. Bolt the indicator to one of the coupling halves and indicate the position of the dial button on the opposite coupling half with a chalk mark. Set the indicator dial to zero at the first position and then rotate both halves of the coupling to a new position where a check reading is to be made. All readings must be made with the dial button located at the chalk mark, and not less than six different sets of readings should be taken. A variation in the dial reading at different positions of coupling rotation will indicate whether the machine has to be raised, lowered, or moved to one side or another to obtain alignment of the circular concentric peripheral surfaces of the two coupling halves within the specified tolerance.

In addition to the above check, a check of the separation of the coupling faces must be made to establish correct alignment. The separation between the faces of the coupling may be

checked with a dial indicator fastened to one coupling half and a reference surface fastened to the other coupling half. Mark the location of the dial button on the reference surface and make all readings with the indicator in this position. Set the dial of the indicator to zero for the first reading and use this as the reference. Be sure to rotate both halves of the coupling the same amount, aligning the button of the indicator and the mark on the reference surface for each of six readings. A variation of the readings at different positions will indicate how the machine has to be adjusted to obtain correct alignment. After each adjustment of the motor, repeat the above procedure to be certain that correct alignment and leveling have been obtained.

FLEXIBLE COUPLING

Units coupled through flexible couplings should be aligned as accurately as possible. As a suggested limit, the two halves should indicate correct alignment within 0.002 in. on both the circular concentric peripheral surfaces and the separation between faces. Although most flexible couplings will withstand greater misalignment than rigid couplings, extreme misalignment can cause vibration possibly resulting in failure of motor bearings and/or shaft.

If the method shown in Fig. 4 is used to check alignment of the machines, correct alignment exists — if the peripheries of the coupling halves are true circles of the same diameter and if the faces are flat — when the separation between the faces is held to within the specified tolerance at all points and a straight-edge lies squarely across the rims at any point. Non-parallel faces will be indicated by a variation in separation of the coupling halves as they are rotated, and a difference in height of the coupling halves will be indicated by the straight-edge and feeler gauge test.

When the coupling halves have been correctly aligned with the motor feet bolted in position, place temporary bolts in two coupling holes for clamping the halves together. Then, ream for a light drive fit through bolt holes for regular coupling bolts.

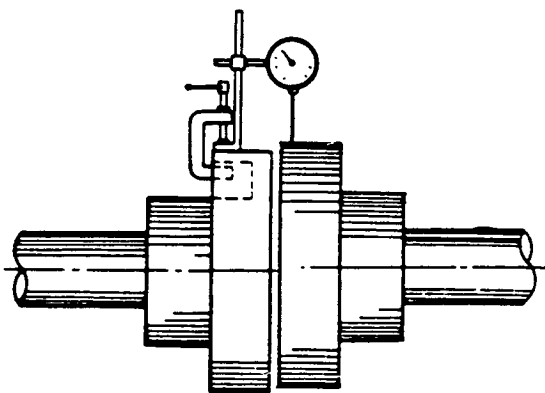
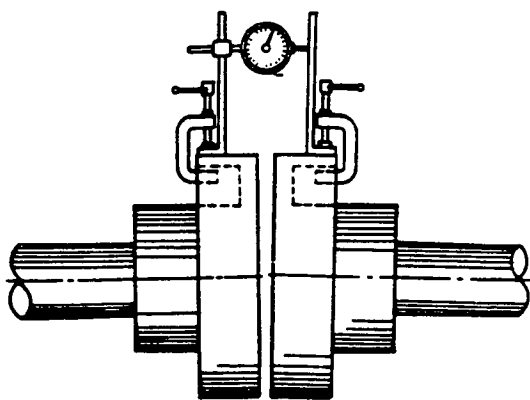


Fig. 3. The preferred method of measuring coupling alignment is with a dial indicator.

- A. Clamp the dial indicator to the coupling as indicated above to measure the circular concentric peripheral surfaces of the coupling halves for parallel alignment.
- B. Clamping a reference surface to the opposite coupling half allows the dial indicator to be used for measuring the separation of the coupling halves for axial alignment as shown below.



BALANCE (DIRECT COUPLED UNITS)

TOSHIBA motors are balanced at the factory to standard NEMA commercial tolerances. However, if direct coupling units have been disassembled in the field, an apparent unbalance may occur if the units are not reassembled with

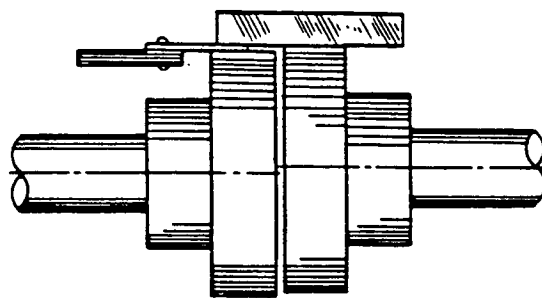
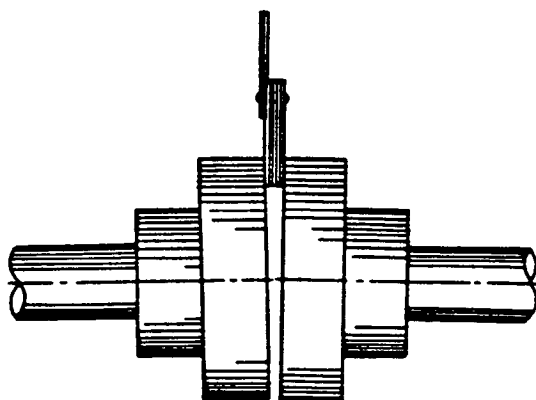


Fig. 4. The straight-edge or thickness gauge or feeler gauge is an alternative method of measuring coupling adjustment.

- A. Use a straight-edge and thickness gauge or feeler gauge to check the alignment of the circular concentric peripheral surfaces of the coupling halves as shown above.
- B. The separation between the faces of the coupling halves can be measured as shown below.



Rigid Coupling tolerances 0.0005 in. to 0.001 in.
Flexible Coupling tolerance: 0.0015 in.

the shafts in the same relative position as they were originally. Should this occur, disconnect the coupling halves and rotate one shaft 90° with respect to the other shaft. Re-connect the coupling and run the unit.

If the unbalance has not disappeared, repeat the above procedure until it does.

CONNECTION DIAGRAMS

A. Wye-connected Dual Voltage (230/460 V) (9 Leads)

| POLE | ODP | TEFC & EXP |
|------|-----------|------------|
| 2 P | 1½HP-7½HP | 1½HP-5HP |
| 4 P | 1HP-5HP | 1HP-5HP |
| 6 P | ¾HP-5HP | ¾HP-5HP |
| 8 P | ¾HP-5HP | ¾HP-5HP |

A-1 Across the Line Starting

| LOW VOLTAGE | HIGH VOLTAGE |
|--|--|
| T4 - T5 - T6 T7 T8 T9 T1 T2 T3 LINE | T4 T5 T6 T7 T8 T9 T1 T2 T3 LINE |

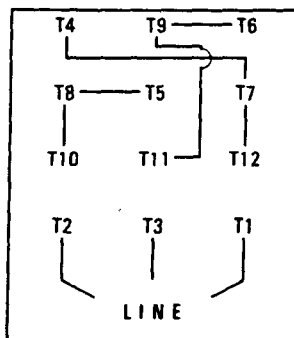
B. Delta-connected Dual Voltage (230/460 V) (12 Leads)

| POLE | ODP | TEFC & EXP |
|------|------------|------------|
| 2 P | 10HP-25½HP | 7½HP-150HP |
| 4 P | 7½HP-200HP | 7½HP-150HP |
| 6 P | 7½HP-125HP | 7½HP-125HP |
| 8 P | 7½HP-100HP | 7½HP-100HP |

B-1 Across the Line Starting

| LOW VOLTAGE | HIGH VOLTAGE |
|---|---|
| T4 T9 T6 T8 T5 T7 T10 T11 T12 T2 T3 T1 LINE | T4 T9 - T6 T8 - T5 T7 T10 T11 T12 T2 T3 T1 LINE |

B-2 575 Volt Connection (see Note 1)

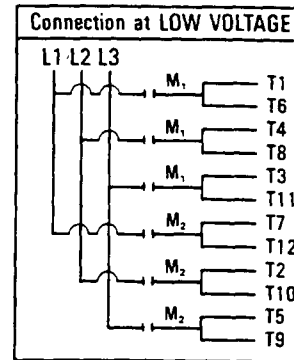


B-3 Wye Start Delta Run

| LOW VOLTAGE | HIGH VOLTAGE |
|---|---|
| L1 L2 L3 T1 M1 T7 T2 M1 T8 T3 M1 T9 T4 M2 T10 T5 M2 T11 T6 M2 T12 | L1 L2 L3 M1 T1 M1 T2 M1 T3 M2 T10 M2 T11 M2 T12 T4 T7 T5 T8 T6 T9 |

| | Start | Run |
|----|-------|-------|
| M1 | Close | Close |
| M2 | Open | Close |
| S | Close | Open |

B-4 Part Winding Starting (see Note 2)



| | Start | Run |
|----|-------|-------|
| M1 | Close | Close |
| M2 | Open | Close |

M₂ should be energized within 2 seconds after M₁ is energized.

NOTES:

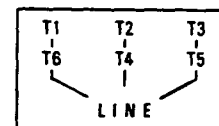
1) Motors can be used on 575-Volt network in accordance with B-2 connection.

2) 4 pole and 6 pole motors are satisfactory for Part Winding starting at low voltage (230 V).

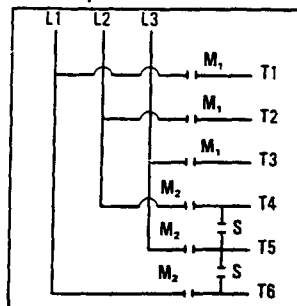
C. Delta-connected Single Voltage (460 V) (6 Leads)

| POLE | ODP | TEFC & EXP |
|------|-------------|-------------|
| 2 P | 300HP-350HP | 200HP-300HP |
| 8 P | 125HP-250HP | 125HP-250HP |

C-1 Across the Line Starting



C-2 Wye Start Delta Run



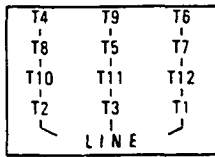
| | Start | Run |
|----|-------|-------|
| M1 | Close | Close |
| M2 | Open | Close |
| S | Close | Open |

CONNECTION DIAGRAMS CONT.

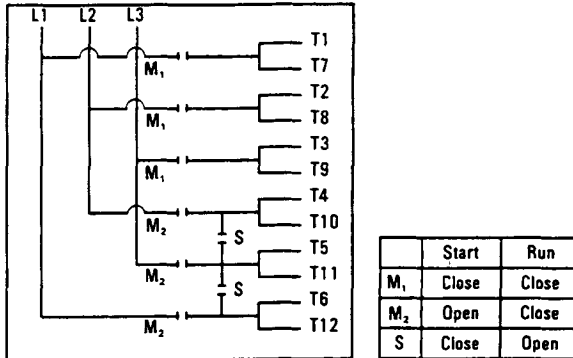
D. Delta-connected Single Voltage (460 V) (12 Leads)

| POLE | ODP | TEFC & EXP |
|------|-------------|-------------|
| 2 P | 400HP-600HP | — |
| 4 P | 250HP-400HP | 200HP-400HP |
| 6 P | 150HP-300HP | 150HP-300HP |

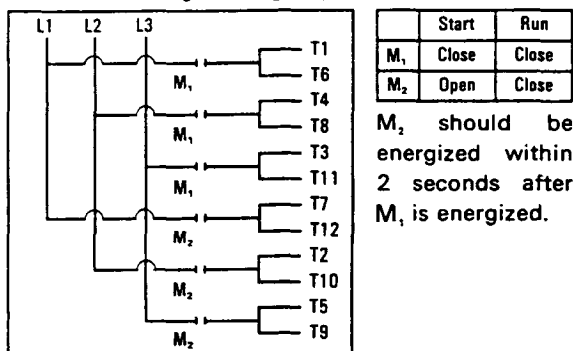
D-1 Across the Line Starting



D-2 Wye Start Delta Run



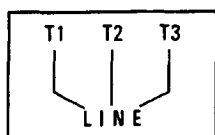
D-3 Part Winding Starting (4 pole and 6 pole motors)



E. Wye-connected 575 Volt Motors (3 Leads)

| POLE | ODP | TEFC & EXP |
|------|-----------|------------|
| 2 P | 1½HP-7½HP | 1½HP-5HP |
| 4 P | 1HP-5HP | 1HP-5HP |
| 6 P | ¾HP-5HP | ¾HP-5HP |
| 8 P | ¾HP-5HP | ¾HP-5HP |

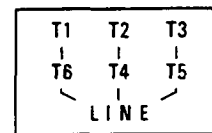
E-1 Across the Line Starting



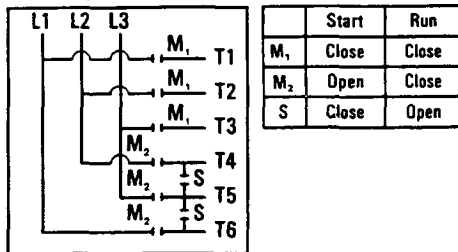
F. Delta-connected 575 Volt Motors (6 Leads)

| POLE | ODP | TEFC & EXP |
|------|------------|------------|
| 2 P | 10HP-500HP | 7½HP-300HP |
| 4 P | 7½HP-400HP | 7½HP-400HP |
| 6 P | 7½HP-300HP | 7½HP-300HP |
| 8 P | 7½HP-250HP | 7½HP-250HP |

F-1 Across the Line Starting



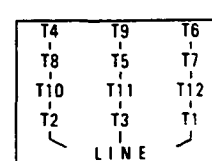
F-2 Wye Start Delta Run



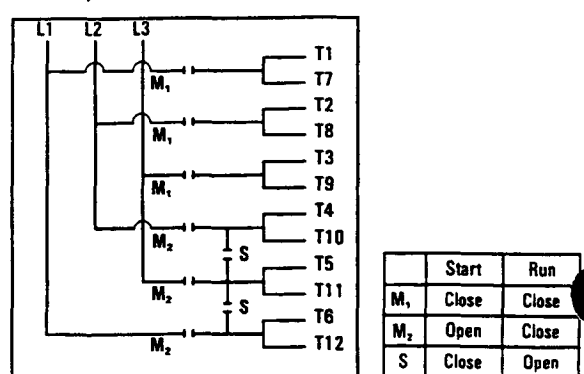
G. Delta-connected 575 Volt Motors (12 Leads)

| POLE | ODP |
|------|-------|
| 2 P | 600HP |

G-1 Across the Line Starting



G-2 Wye Start Delta Run



WARNINGS

Motors built F-1 Assembly will be standard counter clockwise rotation facing non drive end of motor. Motors built F-2 Assembly will have clockwise rotation facing non drive end of motor. With the exception of low voltage TEFC 400T through N587UZ Frame motors, whose rotation will remain counter clockwise.

WARNING

BEFORE STARTING MOTOR, REMOVE ALL UNUSED SHAFT KEYS AND LOOSE ROTATING PARTS TO PREVENT THEM FROM FLYING OFF.

CAUTION: Check direction of motor rotation before coupling motor to load.

WARNING

ROTATING PARTS, SUCH AS COUPLINGS, PULLEYS, EXTERNAL FANS, AND UNUSED SHAFT EXTENSIONS, SHOULD BE PERMANENTLY GUARDED AGAINST ACCIDENTAL CONTACT WITH HANDS OR CLOTHING. THIS IS PARTICULARLY IMPORTANT WHERE THE PARTS HAVE SURFACE IRREGULARITIES SUCH AS KEYS, KEYWAYS OR SET SCREWS.

WARNING

WHEN A LIFTING MEANS IS PROVIDED FOR HANDLING THE MOTOR OR GENERATOR, IT SHOULD NOT BE USED TO LIFT THE MOTOR OR GENERATOR PLUS ADDITIONAL EQUIPMENT SUCH AS GEARS, PUMPS, COMPRESSORS, OR OTHER DRIVEN EQUIPMENT.

WARNING

THE FRAMES AND OTHER METAL EXTERIORS OF MOTORS AND GENERATORS (EXCEPT FOR INSULATED PEDESTAL BEARINGS) USUALLY SHOULD BE GROUNDED TO LIMIT THEIR POTENTIAL TO GROUND IN THE EVENT OF ACCIDENTAL CONNECTION OR CONTACT BETWEEN LIVE ELECTRICAL PARTS AND THE METAL EXTERIORS.

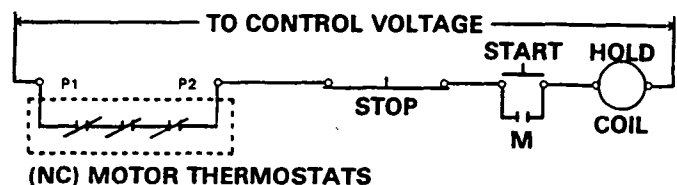
WARNING

WHEN CAREFUL CONSIDERATION OF THE HAZARDS INVOLVED IN A PARTICULAR APPLICATION INDICATE THE MACHINE FRAMES SHOULD NOT BE GROUNDED OR WHEN UNUSUAL OPERATING CONDITIONS DICTATE THAT A GROUNDED FRAME CANNOT BE USED, THE INSTALLER SHOULD MAKE SURE THE MACHINE IS PERMANENTLY AND EFFECTIVELY INSULATED FROM GROUND. IN THOSE INSTALLATIONS WHERE THE MACHINE FRAME IS INSULATED FROM GROUND, IT IS RECOMMENDED THAT APPROPRIATE WARNING LABELS OR SIGNS BE PLACED ON OR IN THE AREA OF THE EQUIPMENT BY THE INSTALLER.

WARNING FOR EXPLOSION-PROOF MOTOR

Disconnect power before working on motor driven equipment. This motor is equipped with an automatic temperature-limiting device. The National Electrical Code and Underwriter's Laboratories require connection of leads P1 and P2 into the control circuit of a manual reset starter per following diagram.

| KLIXON TYPE | AC VOLT | VOLT AMP RATING |
|-------------|----------|-----------------|
| 9700K | 120-600V | 720 VA |



NOTE:

Frame 256T and smaller has two thermostats.

MAINTENANCE

1. INSPECTION

Inspect motor at regular intervals. Keep motor clean and vent openings clear.

2. LUBRICATION

- Frames 143T thru 256T are furnished with double sealed or shielded ball bearings, prelubricated prior to installation. Grease fittings are not supplied and bearings are designed for average 100,000 hours operation under standard conditions. (See table 2 below.)
- Frames 284T thru N587UZ are furnished with double shielded or open ball or roller bearings. (Depending on HP size and/or speed.) It is necessary to relubricate anti-friction bearing motors periodically. (See table 2 below.)
These motors are supplied with provision for greasing and have been lubricated prior to test, however before start-up it is recommended to apply approximately 30 grams (1 oz.) of grease because of possible settling of grease during storage and handling. However, oil leakage around bearing caps indicate overpacking and excess grease should be purged out by operating motor temporarily with relief open.

Table 2. Frequency of Relubrication

| SYNC. RPM RANGE | FRAME RANGE | TYPE OF SERVICE | |
|-----------------------|-----------------|------------------|----------------|
| | | STANDARD DUTY | SEVERE DUTY |
| 3600 | 143T - 256T | * 5 Years | * 3 Years |
| | 284TS - 286TS | 12 Mos. | 4 Mos. |
| | 324TS - N587USS | 9 Mos. | 3 Mos. |
| 1800 | 143T - 256T | * 7 Years | * 3 Years |
| | 284T - 326T | 4 Years | 1.5 Years |
| | 364T - 365T | 2.5 Years | 10 Mos. |
| | 404T - 447TZ | 2 Years | 8 Mos. |
| | 505US - N587UZ | 1.5 Years | 6 Mos. |
| 1200 AND SLOWER | 143T - 256T | * 7 Years | * 3 Years |
| | 284T - 326T | 4 Years | 1.5 Years |
| | 364T - 447TZ | 3 Years | 1 Year |
| | 505US - N587UZ | 2 Years | 8 Mos. |

* The above table shows typical regreasing schedules to be used unless otherwise specified by the motors grease nameplate.

| SERVICE CONDITIONS | |
|--------------------|---|
| STANDARD DUTY | Eight hours per day, light to normal loading, clean condition free from dust. |
| SEVERE DUTY | Twenty-four hours per day, or light to normal shock loading vibration, exposure to dirt or dusty conditions. For very severe conditions where the motor is subject to high vibration or heavy shock loading and vibration use 1/3 of the value shown in the severe duty table. |

Remark * : It is recommended to change bearing grease after the time shown in Table 2.

3. INSTRUCTIONS FOR LUBRICATING

Toshiba motors (284T - N587UZ) are furnished with grease fittings. Before greasing, be sure fittings are clean and free from dirt. Remove grease relief plug or plate and using a low pressure grease gun, pump in the required grease. Do not overgrease. Relubrication intervals are specified in table 2 above. After relubricating, allow motor to run for 10 minutes before replacing relief hardware.

4. RECOMMENDED GREASES FOR STANDARD APPLICATIONS

Use the following greases listed for the given temperature range, unless otherwise shown by the motors grease nameplate.

| OPERATING AMBIENT TEMP. -30°C to 50°C | |
|---|---|
| CHEVRON SRI EXXON UNIREX #2 EXXON POLYREX SHELL DOLIUM R | CHEVRON EXXON CORP. EXXON CORP. SHELL OIL CO |

5. RECOMMENDED GREASES FOR SPECIAL APPLICATIONS

The following greases are recommended for special applications only and should be used only for motors specifically built for such conditions.

| MIN. AMBIENT TEMP. -60°C | |
|-----------------------------------|---------------------------------|
| BEACON 325 | EXXON CORP. |
| MAX. AMBIENT TEMP. 90°C | |
| DOW CORNING 44 EXXON UNIREX S2 | DOW CORNING CORP EXXON CORP. |

WARNING: In general it is not recommended to mix greases of different brands. The mixing of different types of thickeners may destroy the composition and physical properties of the grease. In the event that a different grease is required by the end user, the following steps can be taken. Using the instructions for lubrication, open grease outlet and purge the system as much as possible of the old or unwanted grease. Repeat this same operation after 1 week of service. Consult TOSHIBA/HOUSTON Engineering for further recommendations on grease compatibility.

WARRANTY

Generally, TOSHIBA will correct at it's option, by repair or replacement (f.o.b. a TOSHIBA-AUTHORIZED SERVICE SHOP), any defect in material and workmanship when properly used for a period of one year after installation or 18 months after shipment, whichever comes first. TOSHIBA is not responsible for apparatus returned without proper authorization and identification, improper handling or storage, misapplication of the motor or the driven equipment, defects in the driven equipment or device, or improper circuit protection. The amount of liability shall not exceed the purchase price of the product. In no event shall TOSHIBA have any liability for commercial loss, claims for labor, removal and installation charges or consequential damages of any type. It is expressly agreed that Buyer's remedies expressed in this paragraph are Buyer's exclusive remedies.

RENEWAL PARTS

- Use only genuine TOSHIBA renewal parts.
- When ordering, specify complete information (at least **Model Number** and **Serial Number**) of the motor. Specify quantity and describe part.
- For information and service refer to the nearest TOSHIBA INTERNATIONAL CORPORATION office.

WARNING

EXPLOSION-PROOF MOTORS are constructed to comply with the U L Label Service Procedure Manual. Repairs of EXPLOSION-PROOF MOTORS must be made by the manufacturer or U L listed service center to maintain the U L Listing.

FOR FURTHER INFORMATION CONTACT:

TOSHIBA INTERNATIONAL CORPORATION

Industrial Equipment Division

13131 W. LITTLE YORK RD., P.O. BOX 40906, HOUSTON, TEXAS 77041

195-0014 (06/92)

GARDNER DENVER®

D-9-610
5th Edition
December, 1996

DUROFLOW®

BLOWERS

SERIES: 30, 45 and 70

MODELS

GGB__B__

GGD__B__

GGG__C__

**PARTS LIST
OPERATING AND
SERVICE MANUAL**

**Gardner
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WITH GENUINE DUROFLOW PARTS AND SUPPORT SERVICES
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4. Authorized Distributor service technicians are factory-trained and skilled in blower maintenance and repair. They are ready to respond and assist you by providing fast, expert maintenance and repair services.

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**Gardner Denver Machinery Inc.
1800 Gardner Expressway
Quincy, IL 62305-4024
Phone: (217) 224-8800 (Customer Service)
Fax: (217) 224-7814**

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Whenever a DuroFlow blower requires replacement or repair, Gardner Denver offers an industry unique, factory remanufactured blower exchange program. From its modern Remanufacturing Center in Indianapolis, IN, Gardner Denver is committed to supplying you with the highest quality, factory remanufactured DuroFlow blowers that are guaranteed to save you time, aggravation and money.

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All potentially usable parts are thoroughly cleaned, inspected and analyzed. Only those parts that can be brought back to original factory specifications are remanufactured. Every remanufactured DuroFlow blower receives a new overhaul kit: bearings, gears, seals, sleeves and gaskets.

Extensive Testing

Gardner Denver performs testing that repair houses just don't do. Magnaflux and ultrasonic inspection spot cracked or stressed castings, monochromatic light analysis exposes oil leaks, coordinate measurement machine inspects to $\pm .0001"$, and slip and hot run testing insure that all remanufactured DuroFlow blowers meet factory performance specifications.

Latest Technology

Factory remanufactured DuroFlow blowers incorporate all of the latest new blower design improvements.

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Gardner Denver remanufactured air ends deliver *quality without question . . . year in and year out.*

Call Gardner Denver today for a quote on a DuroFlow Factory Remanufactured Blower.

Phone Number: 800-245-4946 or
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FOREWORD

Duroflow® blowers are the result of advanced engineering and skilled manufacturing. To be assured of receiving maximum service from this machine the owner must exercise care in its operation and maintenance. This book is written to give the operator and maintenance department essential information for day-to-day operation, maintenance and adjustment. Careful adherence to these instructions will result in economical operation and minimum downtime.



DANGER

Danger is used to indicate the presence of a hazard which will cause severe personal injury, death, or substantial property damage if the warning is ignored.



WARNING

Warning is used to indicate the presence of a hazard which can cause severe personal injury, death, or substantial property damage if the warning is ignored.



CAUTION

Caution is used to indicate the presence of a hazard which will or can cause minor personal injury or property damage if the warning is ignored.

NOTICE

Notice is used to notify people of installation, operation or maintenance information which is important but not hazard-related.

SAFETY PRECAUTIONS

Safety is everybody's business and is based on your use of good common sense. All situations or circumstances cannot always be predicted and covered by established rules. Therefore, use your past experience, watch out for safety hazards and be cautious. Some general safety precautions are given below:



DANGER

Failure to observe these notices could result in injury to or death of personnel.

- Keep fingers and clothing away from blower inlet and discharge ports, revolving belts, sheaves, drive coupling, etc.
- Do not use the air discharge from this unit for breathing – not suitable for human consumption.
- Do not loosen or remove the oil filler plug, drain plugs, covers, or break any connections, etc., in the blower air or oil system until the unit is shut down and the air pressure has been relieved.
- Electrical shock can and may be fatal.
- Blower unit must be grounded in accordance with the National Electrical Code. A ground jumper equal to the size of the equipment ground conductor must be used to connect the blower motor base to the unit base.
- Open main disconnect switch, tag and lockout before working on the control.
- Disconnect the blower unit from its power source, tag and lockout before working on the unit – the machine may be automatically controlled and may start at any time.



WARNING

Failure to observe these notices could result in damage to equipment.

- Stop the unit if any repairs or adjustments on or around the blower are required.
- Disconnect the blower unit from its power source, tag and lockout before working on the unit – the machine may be automatically controlled and may start at any time.
- Do not exceed the rated maximum speed shown on the nameplate.
- Do not operate unit if safety devices are not operating properly. Check periodically. Never bypass safety devices.

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DUROFLOW BLOWERS – 30, 45 & 70 SERIES MATRIX/MENU

NOTICE TO CUSTOMER – To find the construction options for your blower unit, FILL IN THE BALANCE OF LETTERS OR NUMBERS FROM YOUR UNIT NAMEPLATE

COLUMN NUMBER:

G

1 2 3 4 5 6 7 8 9 10 11

FOLLOW THE LINE DOWN AND OVER FROM EACH SPACE THUS FILLED IN TO FIND THE APPROPRIATE CONSTRUCTION OPTION WITH WHICH YOUR MACHINE IS EQUIPPED.

COLUMN 1 – BASIC DESIGNATOR

COLUMN 2 – PRODUCT FAMILY

G. INDUSTRIAL BLOWER

* M. TRUCK BLOWER

COLUMN 3 – GEAR DIAMETER

B. 3" – 30 Series

D. 4.5" – 45 Series

G. 7" – 70 Series

COLUMN 4 – CASE LENGTH

30 Series

45 Series

70 Series

A. 4"

4"

9"

B. 6"

6"

12"

C.

9"

15"

D.

12"

18"

E.

18"

23"

F.

28"

COLUMN 5 – CONSTRUCTION

A. VERTICAL-TOP HAND-CENTRAL TIMED

B. VERTICAL-BOTTOM HAND-CENTRAL TIMED

C. HORIZONTAL-LEFT HAND-CENTRAL TIMED

D. HORIZONTAL-RIGHT HAND-CENTRAL TIMED

* E. SCHRAMM: VERTICAL-TOP HAND-CENTRAL TIMED

COLUMN 6 – DESIGN VERSION

COLUMN 7 – ADDITIONAL DESCRIPTION

A. STANDARD, NO MODIFICATION

* C. LEAK RESISTANT

* E. STEP-UP DRIVE

COLUMNS 8 THRU 11 – MODIFICATION NUMBER *

* NOT INCLUDED IN THIS PUBLICATION, CONSULT FACTORY.

SECTION 1 GENERAL INFORMATION

INSPECTION

Before uncrating, check the packing slip carefully to be sure all the parts have been received. All accessories are listed as separate items on the packing slip, and small important accessories such as relief valves can be overlooked or lost. After every item on the packing slip has been checked off, uncrate carefully. Register a claim with the carrier for lost or damaged equipment.

The inlet and discharge openings are fitted with protective covers to prevent dirt and moisture from entering the blower during shipping and installation.

NOTICE

Do not remove and dispose of the covers until final checking and installation.

Covers are lined with a "Corrosion Inhibitor" which will inhibit rust for a period of six months. Retain covers for use in reshipment or relocation of the unit.

Temporarily remove the protective covers and inspect interior of air chamber for foreign material or heavy rusting. Turn driveshaft to assure that lobes rotate smoothly without binding. New blowers may be difficult to turn by hand due to friction of the air seals. Once in motion however, there should be no indication of interference between the rotors and the housing or endplates. Report any suspected mechanical problems immediately to your authorized DuroFlow distributor.

REMOVING PROTECTIVE MATERIALS AT START-UP

Blower inlet and discharge are temporarily capped to keep out dirt and other contaminants during shipment. These covers must be removed before start-up.

WARNING

Failure to remove covers from blower inlet and discharge prior to start-up will cause machine damage.

STORAGE

Your DuroFlow blower was packaged at the factory with adequate protection to permit normal storage for up to six (6) months. Under the best of storage conditions there is still a potential for damage to occur. Extended storage preparation is available from the factory, prior to shipment, at a small additional charge. If the unit is to be stored under adverse conditions or for extended periods of time, additional measures should be taken to prevent unwarrantable damage.

1. Store the blower in a clean, dry area.
2. Make certain inlet and discharge air ports are tightly covered to prevent foreign material from entering the air chamber.
3. All exposed, non-painted surfaces should be protected against rust and corrosion.
4. Make sure all vent breathers are in place.
5. Provide adequate protection to avoid accidental mechanical damage.
6. In high humidity or corrosive environments, additional measures may be required to prevent rusting of the internal surfaces. Mist spraying the impellers and air chamber with a rust preventative will protect these surfaces from rusting. To prevent rusting of gears and bearings, fill the oil reservoirs completely with normal operating oil.

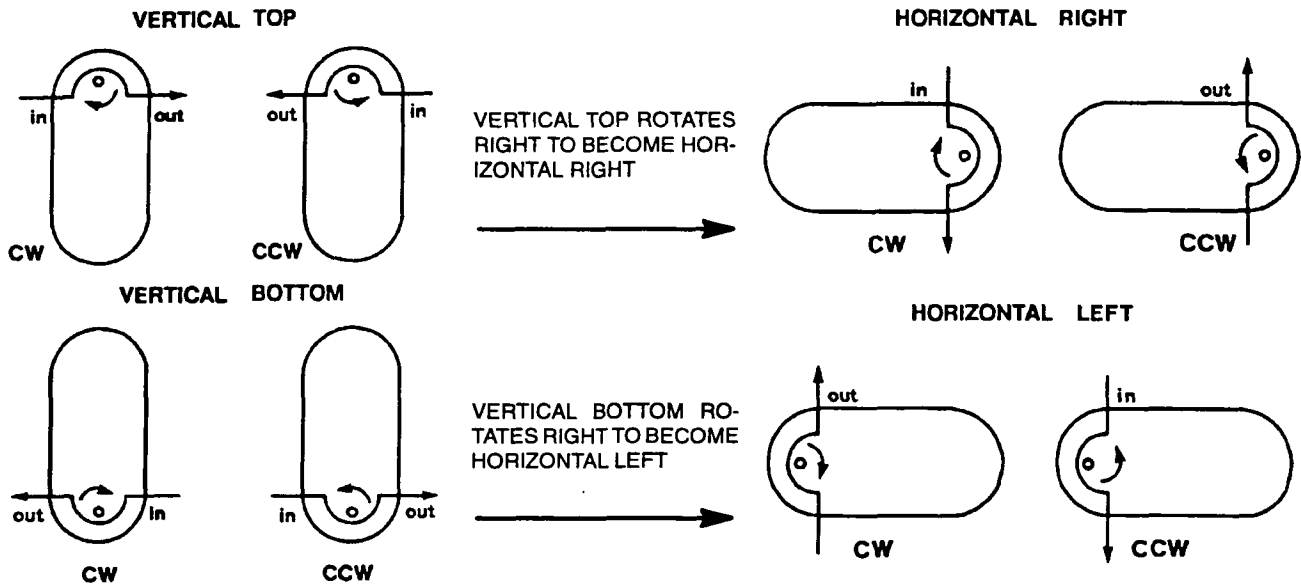
CAUTION

Before running the blower, drain the oil and replace to the proper operating level with clean, fresh lubricant.

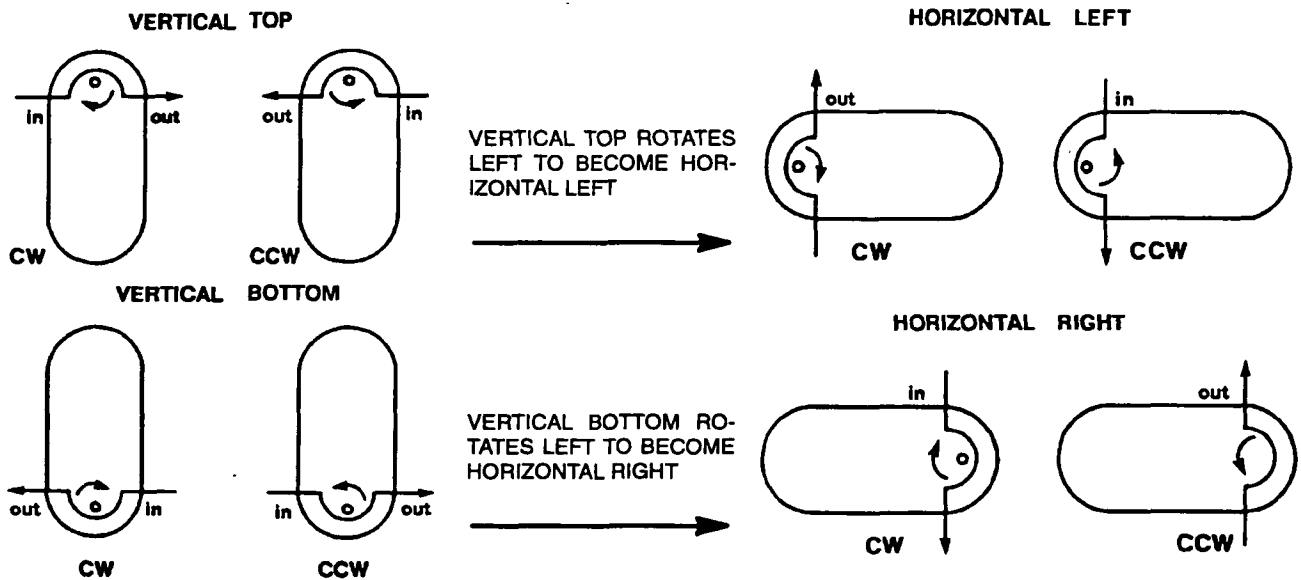
WARNING

Rotating components will cause severe injury in case of personal contact. Keep hands away from blower inlet and discharge ports.

30 SERIES



45 & 70 SERIES



SHAFT ROTATION KEY: CW = CLOCKWISE
CCW = COUNTERCLOCKWISE

NOTE: When changing configurations be sure to relocate Oil Fill, Oil Drain and Breather Filters into their proper position. 30 & 45 Series blowers require a mounting foot change with a configuration change. 70 Series blowers use the same mounting feet for all configurations.

FIGURE 1-1 - BLOWER MOUNTING CONFIGURATIONS

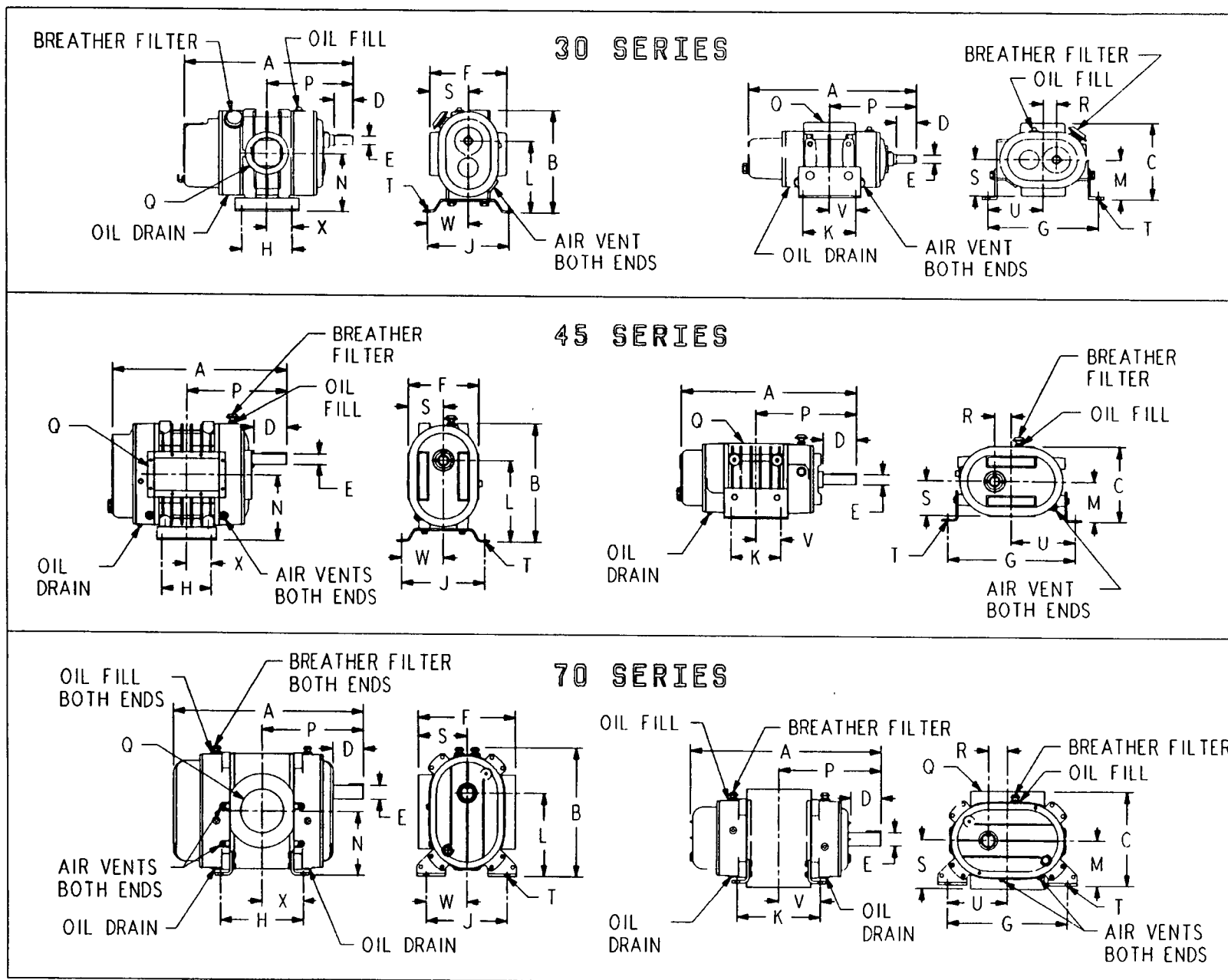


FIGURE 1-2 - OUTLINE

| BLOWER OUTLINE DIMENSION CHART | | | | | | | | | | | | | |
|---|------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|---------|---------|
| Dimensions | Models | | | | | | | | | | | | |
| | 3004 | 3006 | 4504 | 4506 | 4509 | 4512 | 4518 | 7009 | 7012 | 7015 | 7018 | 7023 | 7028 |
| A | 16.64 | 18.64 | 17.84 | 21.34 | 24.34 | 27.34 | 33.42 | 32.42 | 35.43 | 38.44 | 41.44 | 46.44 | 51.44 |
| B | 11.62 | 11.62 | 16.37 | 16.37 | 16.37 | 16.37 | 16.37 | 23.62 | 23.62 | 23.62 | 23.62 | 23.62 | 23.62 |
| C | 8.81 | 8.81 | 10.50 | 10.50 | 10.50 | 10.50 | 12.12 | 17.25 | 17.25 | 17.25 | 17.25 | 17.25 | 17.25 |
| D | 2.00 | 2.00 | 3.13 | 4.63 | 4.63 | 4.63 | 4.63 | 5.68 | 5.68 | 5.64 | 5.64 | 5.62 | 5.62 |
| E DIA. | 1.000 | 1.000 | 1.4375 | 1.4375 | 1.4375 | 1.4375 | 1.4375 | 2.500 | 2.500 | 2.500 | 2.500 | 2.500 | 2.500 |
| F | 8.62 | 8.62 | 9.75 | 9.75 | 9.75 | 9.75 | 13.00 | 18.00 | 18.00 | 18.00 | 18.00 | 18.00 | 18.00 |
| G | 12.50 | 12.50 | 17.50 | 17.50 | 17.50 | 17.50 | 17.50 | 22.00 | 22.00 | 22.00 | 22.00 | 22.00 | 22.00 |
| H | 4.00 | 5.50 | 4.88 | 6.88 | 6.88 | 9.88 | 15.88 | 12.50 | 15.50 | 18.50 | 21.50 | 26.50 | 31.50 |
| J | 9.00 | 9.00 | 11.50 | 11.50 | 11.50 | 11.50 | 11.50 | 15.00 | 15.00 | 15.00 | 15.00 | 15.00 | 15.00 |
| K | 4.00 | 5.50 | 5.00 | 7.00 | 7.00 | 10.00 | 16.00 | 12.50 | 15.50 | 18.50 | 21.50 | 26.50 | 31.50 |
| L | 8.06 | 8.06 | 11.35 | 11.35 | 11.35 | 11.35 | 11.35 | 15.25 | 15.25 | 15.25 | 15.25 | 15.25 | 15.25 |
| M | 4.50 | 4.50 | 5.62 | 5.62 | 5.62 | 5.62 | 5.62 | 8.25 | 8.25 | 8.25 | 8.25 | 8.25 | 8.25 |
| N | 6.56 | 6.56 | 9.10 | 9.10 | 9.10 | 9.10 | 9.10 | 11.75 | 11.75 | 11.75 | 11.75 | 11.75 | 11.75 |
| P | 8.35 | 9.35 | 10.02 | 12.52 | 14.02 | 15.52 | 18.52 | 17.49 | 18.99 | 20.47 | 21.97 | 24.47 | 26.97 |
| Q | 2-1/2" NPT | 3" NPT | * | * | * | * | 8" FLG | 6" NPT | 8" FLG | 8" FLG | 10" FLG | 12" FLG | 12" FLG |
| R | 1.50 | 1.50 | 2.25 | 2.25 | 2.25 | 2.25 | 2.25 | 3.50 | 3.50 | 3.50 | 3.50 | 3.50 | 3.50 |
| S | 4.31 | 4.31 | 4.88 | 4.88 | 4.88 | 4.88 | 6.50 | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 |
| T DIA. | .56 | .56 | .69 | .69 | .69 | .69 | .69 | .88 | .88 | .88 | .88 | .88 | .88 |
| U | 7.75 | 7.75 | 8.75 | 8.75 | 8.75 | 8.75 | 8.75 | 11.00 | 11.00 | 11.00 | 11.00 | 11.00 | 11.00 |
| V | 2.00 | 2.75 | 2.50 | 3.50 | 3.50 | 5.00 | 8.00 | 6.25 | 7.75 | 9.25 | 10.75 | 13.25 | 15.75 |
| W | 4.50 | 4.50 | 5.75 | 5.75 | 5.75 | 5.75 | 5.75 | 7.50 | 7.50 | 7.50 | 7.50 | 7.50 | 7.50 |
| X | 2.00 | 2.75 | 2.44 | 3.44 | 3.44 | 4.94 | 7.94 | 6.25 | 7.75 | 9.25 | 10.75 | 13.25 | 15.75 |
| * See Figure 2-5, Page 9, for available connectors. | | | | | | | | | | | | | |
| APPROXIMATE WEIGHT | | | | | | | | | | | | | |
| MODEL | 3004 | 3006 | 4504 | 4506 | 4509 | 4512 | 4518 | 7009 | 7012 | 7015 | 7018 | 7023 | 7028 |
| LBS. | 120 | 135 | 235 | 260 | 290 | 335 | 470 | 820 | 920 | 1000 | 1080 | 1160 | 1260 |

FIGURE 1-3 - BLOWER OUTLINE DIMENSION CHART

SECTION 2 INSTALLATION

LOCATION

Whenever possible, install the blower in a clean and dry place that is both well lighted and well ventilated. Provide plenty of room for easy inspection and maintenance.

FOUNDATION AND BASE

For permanent installations we recommend concrete foundations be provided, and the equipment should be grouted to the concrete. It is necessary that a suitable base be used, such as steel combination base under the blower and motor, or a separate sole plate under each. Before grouting, equipment must be leveled, free of all strains, and anchored so no movement will occur during curing of grout. After grout has completely hardened, a recheck is necessary to compensate for shrinkage. If required, add shims under blower feet after final tightening of foundation anchor bolts to remove strain from the blower housing.

Where jack screws or wedges are used during grouting, they must be backed off or removed before final tightening of anchor bolts.

Where a concrete foundation is not feasible, care must be taken to insure that equipment is firmly anchored to adequate structural members. The blower must be installed on a flat, level surface and bolted down evenly to prevent warping or strain. Internal clearances are very critical and serious damage or failure can result from housing distortion.

NOTICE

If the unit is not flat within .002 of an inch, it will be necessary to shim the blower feet at installation.

MOUNTING CONFIGURATIONS

All DuroFlow blowers are center timed allowing rotation in either direction.

DuroFlow blowers are shipped in the vertical configuration (horizontal airflow.) If a horizontal configuration is desired, the blower can be laid on its side after repositioning breathers, oil filler drain plugs and mounting feet as indicated in the installation drawing, FIGURE 1-2, page 5. **To assure proper lubrication, the blower must be laid over in the direction that places the oil sight glass(es) below the horizontal centerline of the blower.** See FIGURE 1-1, page 4, for additional configuration information.

When converting 30 and 45 series blowers from vertical to horizontal configurations, the horizontal mounting feet are required. Order horizontal mounting feet from your DuroFlow Distributor. The 70 series blowers can be converted from vertical to horizontal configurations utilizing the same four (4) feet originally shipped with the blower.

The blower must be mounted level with the driveshaft in the horizontal position. Some models have interconnected oil sumps and operation in an out-of-level condition will result in inadequate lubricant distribution and subsequent premature blower failure.

DRIVE INSTALLATION

When selecting a V-belt drive, check to be sure the shaft overhung load limitation is not exceeded.

Overhung Load Calculations and Limitations – An excessive overhung condition exists when the belt pull on the blower shaft exceeds the maximum allowable moment listed in "Maximum Allowable Moment" chart in FIGURE 2-1, page 8. Excessive overhung load conditions must be avoided or bearing failure and shaft breakage will result.

WARNING

Exceeding overhung load limitations leads to unwarrantable premature bearing failure and shaft breakage.

The location of the sheave on the blower shaft greatly affects the stress in the shaft. The optimum blower sheave positioning is as close as possible to the blower drive cover, not to exceed dimension "C" shown in maximum allowable moment chart, FIGURE 2-1, page 8.

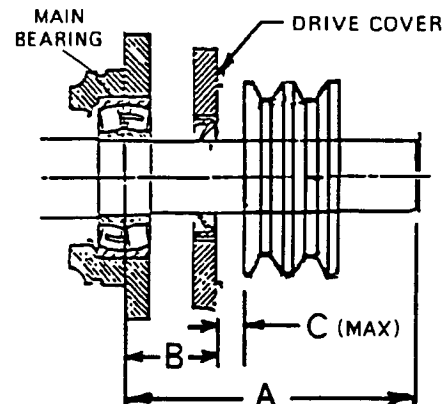
To calculate the shaft moment for a given V-belt drive arrangement, first calculate the belt pull using the formula for belt pull in FIGURE 2-1, page 8. Insert the calculated belt pull into the formula for calculation of shaft moment in FIGURE 2-1, page 8, to arrive at the calculated shaft moment.

The calculated shaft moment must not exceed the maximum allowable moment listed in the chart, FIGURE 2-1, page 8. If the calculated shaft moment exceeds the maximum allowable moment:

- Increase Sheave Diameters to Reduce Belt Pull
- Use Jackshaft Drive
- Use Direct Coupled or Gearbox Drive

| Series | Gear Diameter (Inches) | Dimensions (Inches) | | | Maximum Allowable Moment (LB-IN) |
|-------------|------------------------|---------------------|------|-----|----------------------------------|
| | | A | B | C | |
| 30 | 3 | 4.75 | 1.87 | .94 | 1449 |
| 45 | 4.5 | 7.38 | 2.75 | .75 | 3591 |
| 70 | 7 | 9.45 | 3.82 | .63 | 14469 |
| * 4504 Only | 4.5 | 5.88 | 2.75 | .75 | 3591 |

* Applies to 4504 only.



MAXIMUM ALLOWABLE MOMENT

DRIVE SHAFT ILLUSTRATION

| Z | Ac | Z | Ac | Z | Ac | Z | Ac | Z | Ac | Z | Ac |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 0.000 | 1.000 | 0.250 | 0.966 | 0.500 | 0.926 | 0.750 | 0.879 | 1.000 | 0.823 | 1.250 | 0.751 |
| 0.025 | 0.997 | 0.275 | 0.962 | 0.525 | 0.922 | 0.775 | 0.874 | 1.025 | 0.816 | 1.275 | 0.742 |
| 0.050 | 0.994 | 0.300 | 0.958 | 0.550 | 0.917 | 0.800 | 0.869 | 1.050 | 0.810 | 1.300 | 0.734 |
| 0.075 | 0.990 | 0.325 | 0.954 | 0.575 | 0.913 | 0.825 | 0.864 | 1.075 | 0.803 | 1.325 | 0.725 |
| 0.100 | 0.987 | 0.350 | 0.951 | 0.600 | 0.908 | 0.850 | 0.858 | 1.100 | 0.796 | 1.350 | 0.716 |
| 0.125 | 0.983 | 0.375 | 0.947 | 0.625 | 0.904 | 0.875 | 0.852 | 1.125 | 0.789 | 1.375 | 0.706 |
| 0.150 | 0.980 | 0.400 | 0.943 | 0.650 | 0.899 | 0.900 | 0.847 | 1.150 | 0.782 | 1.400 | 0.697 |
| 0.175 | 0.977 | 0.425 | 0.939 | 0.675 | 0.894 | 0.925 | 0.841 | 1.175 | 0.774 | 1.425 | 0.687 |
| 0.200 | 0.973 | 0.450 | 0.935 | 0.700 | 0.889 | 0.950 | 0.835 | 1.200 | 0.767 | | |
| 0.225 | 0.969 | 0.475 | 0.930 | 0.725 | 0.884 | 0.975 | 0.829 | 1.225 | 0.759 | | |

ARC OF CONTACT FACTORS

$$\text{Belt Pull} = \left[\frac{2.5 - A_c}{A_c} \right] \left[\frac{125954 \times \text{HP} \times \text{S.F.}}{D \times \text{RPM}} \right]$$

Key: A_c = Arc of Contact Factor (Refer to Arc of Contact Factors Chart above)
 H_p = Blower Horsepower for Operating Conditions
 $S.F.$ = Drive Service Factor (use 1.4 S.F. for continuous duty applications)
 D = Blower Sheave Pitch Diameter in Inches
 RPM = Blower Sheave Speed
 Z = $\frac{\text{Large Sheave Pitch Diameter (in)} - \text{Small Sheave Pitch Diameter (in)}}{\text{Sheave Center Distance (in)}}$

CALCULATION OF BELT PULL

$$\text{Shaft Moment (LB-IN)} = \text{Belt Pull} \times \left[B + C + \frac{(\text{Sheave Width})}{2} \right]$$

CALCULATION OF SHAFT MOMENT

FIGURE 2-1 - BELT DRIVE OVERHUNG LOAD CALCULATIONS

Driver Location – To properly balance the air load stress on the blower drive shaft, locate the driver on the inlet side for a vertical mounted blower and on the shaft side for a horizontal mounted blower.

Belt Drive Alignment – Belt drives must be carefully aligned, with the motor and blower sheaves parallel to each other and in the same plane. Belt tension should be carefully adjusted according to the belt manufacturer's recommendations using a Tension Tester.

⚠ WARNING

Overtightening belts produces heavy bearing loads and leads to unwarrantable premature failure.

On direct drive blowers, align the couplings so that the offset and angular misalignment does not exceed .003" total indicator reading (TIR). Lubricate coupling according to manufacturer's specification. With factory installed drives, proper alignment has been established before shipment. During shipping, handling and installation, it is likely that the alignment has been disturbed and final adjustment must be made before start-up.

PIPING

All 30 Series DuroFlow blowers have female threaded inlet and discharge connections. The connections are large enough to handle maximum volume with minimum friction loss. Reducing the pipe diameter on either inlet or discharge will create unwanted restrictions that increase the overall pressure differential and discharge temperature of the blower.

DuroFlow 45 series, 4504 through 4512 blowers, can accept a variety of inlet and discharge connectors. Refer to FIGURE 2-2, below, for a listing of available connectors. 4504 through 4512 blowers are shipped without inlet and discharge connectors. Contact your DuroFlow Distributor to order connectors.

The 4518 and all 70 Series DuroFlow blowers have flat face inlet and discharge flanges with ANSI 125 lb. bolt patterns.

When installing the blower, avoid subjecting the inlet and discharge connections to strains caused by misalignment of the connecting pipes. Never allow the blower to carry the weight of the pipe.

Piping strain and misalignment stress will distort the blower during operation, resulting in loss of critical internal clearances. Loss of internal clearances will result in serious machine damage and premature, unwarrantable blower failure.

Whenever possible, install a spool or sleeve-type expansion joint between the blower and the piping. Where a flexible connection is not possible, the weight of the rigid connection and piping must be separately supported, and thermal pipe growth must be accommodated.

⚠ WARNING

Thoroughly clean all system piping internally before connecting to the blower.

DUROFLOW INLET AND DISCHARGE CONNECTORS

TWO CONNECTIONS REQUIRED FOR EACH BLOWER

NOTE: CONNECTORS ARE REUSABLE

| Dur Flow Model | CONNECTOR PART NUMBER | | | | | |
|-------------------|--------------------------------------|-------------------------------------|--------------------------------------|-------------------------------------|--------------------------------------|-------------------------------------|
| | 4" Line Size Connector (Short) | 4" Line Size Connector (Long) | 5" Line Size Connector (Short) | 5" Line Size Connector (Long) | 6" Line Size Connector (Short) | 4" Line Size Connector (Long) |
| 4504 | N/A | DF141575 | N/A | N/A | N/A | N/A |
| 4506 | DF137356 | DF137357 | N/A | N/A | N/A | N/A |
| * 4509 | DF138987 | N/A | DF149559 | DF137346 | N/A | N/A |
| 4512 | N/A | N/A | N/A | N/A | DF1471748 | DF137344 |

ALL CONNECTORS HAVE FEMALE THREADED CONNECTIONS.

* Use 5" connectors above 3000 RPM on pressure service to keep line losses to a minimum.

FIGURE 2-2 – INLET AND DISCHARGE CONNECTORS

SECTION 3 LUBRICATION

Every DuroFlow blower is lubricated and thoroughly tested at the factory, after which the oil is drained for shipping.

WARNING

DuroFlow blowers are shipped dry from the factory. Do not attempt to operate the blower before following proper lubrication instructions. Permanent damage to the gears, bearings and seals will occur.

All DuroFlow blowers are splash oil lubricated at both the gear and drive ends. Oil is distributed around the gear housing and drive end chamber by the gears and specially designed oil flingers.

FILLING PROCEDURE

For 30 and 45 series models, the oil fill port is located on the top of the blower at the driveshaft end (see FIGURE 1-2, page 5). The two oil sumps are connected by a passageway through the housing.

On 70 series models and 45 series truck models (units with two oil sight glasses), **each end** of the blower has a separate oil sump. Oil must be added to each end of the blower through the oil breather ports (see FIGURE 1-2, page 5).

WARNING

Failure to add oil to each end of the blower on 70 series models and 45 series truck models will result in damage to the blower.

For 30, 45 and 70 series models, add oil until the oil levels stabilize at the center of the sight glass(es).

Oil level at the sight glass must be established when the blower is not operating. When the blower is running, depending upon the blower rotation, the oil level will show above or below the centerline of the sight glass. The 70 series "C" design version with a column gauge indicates the actual oil level during operation.

Do not overfill as this will cause excessive oil temperature and decreased lubricant life.

WARNING

Do not overfill as this will cause excessive oil temperature and decreased lubricant life, leading to premature failure of the unit.

RECOMMENDED LUBRICANT

| Blower Discharge Temperature | | Factory Tested Recommended and Approved Lubricant |
|------------------------------|--------------|---|
| ° F | ° C | |
| 32° | 0° | AEON PD Synthetic Blower Lubricant One Superior Lubricant For All Operating Temperatures |
| 100° | 38° | |
| 275° | 135° | |
| 350° | 177° | |
| AEON PD | 1 Qt. Bottle | Part No. 28G23 |
| AEON PD | 12 Qt. Case | Part No. 28G24 |
| AEON PD | 5 Gal. Pail | Part No. 28G25 |
| AEON PD | 55 Gal. Drum | Part No. 28G28 |

FIGURE 3-1 - RECOMMENDED LUBRICANT

AEON PD is formulated especially for positive displacement blower service to provide maximum blower protection at any operating temperature. One filling of AEON PD will last a minimum of 4 times longer than a premium mineral oil, depending on actual operating conditions. Order AEON PD from your DuroFlow Distributor or call DuroFlow Customer Service at 217-224-8800.

If not using AEON PD synthetic blower lubricant, use an oil with rust and oxidation inhibitors, anti-foam additives and the viscosities listed in FIGURE 3-3, page 11.

| Series | Oil Fill Ports | Vertical Mounting | Horizontal Mounting |
|----------|---|-------------------|---------------------|
| 30 | One Port – Shaft & Gear Ends interconnected | 16 oz. | 28 oz. |
| 45 | One Port – Shaft & Gear Ends Interconnected | 29 oz. | 55 oz. |
| 45 Truck | One Port – Shaft End | 13 oz. | 23 oz. |
| | One Port – Gear End | 16 oz. | 32 oz. |
| 70 | One Port – Shaft End | 52 oz. | 91 oz. |
| | One Port – Gear End | 66 oz. | 125 oz. |

FIGURE 3-2 – APPROXIMATE OIL CAPACITIES

| Blower Discharge Temperature | Oil Grade ISO | Oil Viscosity SUS @ 100° F |
|--------------------------------------|---------------|----------------------------|
| 32° to 100° F (0° to 38° C) | 100 | 465 |
| 100° to 225° F (38° F to 105° F) | 150 | 700 |
| 225° F to 300° F (105° to 149° C) | 220 | 1000 |
| Over 300° F (149° C) | * | * |

FIGURE 3-3 – VISCOSITY RECOMMENDATION

LUBRICATION SERVICE

Add fresh oil as required to maintain proper level. If

premium grade mineral oil is used, the oil should be drained, the gearbox flushed and the oil replaced every 500 hours of operation or more frequently if inspection indicates oil breakdown. With AEON PD synthetic blower lubricant, perform the above oil change maintenance after 2000 hours of operation. For the location of the oil drain plug see FIGURE 1-2, page 5.

Air Seal Vent Systems

All DuroFlow blowers are designed with a vent opening between the air chamber seal and the oil sump seal that vents to atmosphere any air which escapes from the air chamber. The vent prevents pressurization of the oil sump and must be left open to atmosphere. The vent holes are tapped 3/8" NPT to permit installation of a venting line. Do not plug these vent holes (see FIGURE 1-2, page 5).

WARNING

Do not plug vent holes or oil sumps may pressurize causing loss of oil, excessive heat and serious damage to the machine.

Oil Sump Breathing System

All DuroFlow blowers are designed to permit their oil systems to breathe freely to prevent pressurization of the oil sumps. Breather filters are required to keep contaminants from entering the oil sumps (see Figure 1-1, page 4). Series 30 and 45 models require only one breather filter due to their interconnected shaft and gear end oil sumps. In these models, breathers equalize the pressure between the interconnected oil sumps and permit the equal distribution of oil between the gear and drive oil sumps. Series 70 models and 45 series truck models do not have interconnected oil sumps and require two breather filters, one on each sump.

Breather filters are easily cleaned by washing in commercial solvent and drying with compressed air. Clean at every oil change to assure proper venting.

SECTION 4 OPERATION

Future operating problems can be avoided if proper precautions are observed when the equipment is first put into service.

Before starting under power, the blower should be turned over by hand to make certain there is no binding, or internal contact.

LIMITATIONS

Each size blower has limits on pressure differential, running speed, and discharge temperature which must not be exceeded. These limits are shown in FIGURE 4-1, page 13.



WARNING

Operating beyond the specified operating limitations will result in damage to the unit.

To accurately determine actual blower operating conditions, it is important that all pressure and temperature recordings are made directly at the ports of the blower where these conditions are at their maximum.

Relief valves **MUST** be used to protect the blower against excessive pressure or vacuum conditions. These valves should be tested at initial start up to be sure they are adjusted to relieve at 2 psi above the maximum allowable pressure and at 2" HG below the maximum allowable vacuum for the blower. Periodic testing of relief valves is suggested to assure that they are functioning.

NOTICE

Relief valves should be placed as close as possible to the blower inlet on vacuum systems or discharge on pressure systems.

Check valves must be installed on the discharge side of the blower on a pressure system and on the inlet side of the blower on a vacuum system to eliminate product ingestion resulting from autorotation and blow back during equipment shutdown.

SAFETY PRECAUTIONS

1. Do not operate the blower with an open inlet or discharge port.
2. Do not exceed specified vacuum or pressure limitations.
3. Do not operate above or below recommended blower speed range.
4. The blower is not to be used where non-sparking equipment is specified. Contact your DuroFlow Distributor for non-sparking requirements.
5. Do not operate the blower without belt guard or coupling shield properly installed.
6. Do not exceed the manufacturer's specified rim speed limit for sheaves or couplings.
7. The blower and blower discharge piping may be extremely hot and can cause skin burns on contact.
8. Do not exceed the manufacturer's certification levels for vacuum or pressure vessels.

| MAXIMUM OPERATING LIMITATIONS | | | | |
|---|------|---------------------------------|--------------------------|-----------------------------|
| Size | RPM | Differential Pressure PSI | Dry * Vacuum In HG | Discharge Temperature °F |
| 3004 | 4000 | 15 | 15 | 350 |
| 3006 | 4000 | 15 | 15 | 350 |
| 4504 | 4000 | 15 | 15 | 350 |
| 4506 | 4000 | 15 | 15 | 350 |
| 4509 | 4000 | 15 | 15 | 350 |
| 4512 | 4000 | 15 | 15 | 350 |
| 4518 | 4000 | 10 | 16 | 325 |
| 7009 | 2650 | 15 | 15 | 350 |
| 7012 | 2650 | 15 | 15 | 350 |
| 7015 | 2650 | 15 | 15 | 350 |
| 7018 | 2650 | 15 | 15 | 350 |
| 7023 | 2600 | 12 | 16 | 325 |
| 7028 | 2600 | 10 | 16 | 325 |
| DO NOT EXCEED THESE LIMITS | | | | |
| * Increased vacuum levels are attainable with water injection. Contact your DuroFlow Distributor. | | | | |
| <div> <div>NOTICE</div> <div> Blower speed, line losses, elevation, and increased inlet temperatures affect actual blower performance. Care must be taken to consider these factors when designing your system so that blower limitations are not exceeded. </div> </div> | | | | |

FIGURE 4-1 – MAXIMUM OPERATING LIMITATIONS

BLOWER STARTUP CHECKLIST

This startup procedure should be followed during the initial installation and after any shutdown periods or after the blower has been worked on or moved to a new location. It is suggested that the steps be followed in sequence and checked off (✓) in the boxes provided.

- ☐ 1. Check to make certain that the blower has been properly lubricated with AEON PD Synthetic Blower Lubricant. Proper oil level cannot be overemphasized. Too little oil will ruin bearings and gears. Too much oil will overheat the lubricant and lead to serious blower damage.
- ☐ 2. Check to make sure all oil sump breather filters are installed in their proper location. Oil leakage will occur if they are improperly located.
- ☐ 3. Check the unit and all piping for foreign material and clean if required.
- ☐ 4. Check the inlet or inline filter to make sure it is not plugged causing dangerous inlet restriction.
- ☐ 5. Check the preload of the feet and the alignment of the drive. Feet that are bolted down in a bind can cause case distortion and internal rubbing. A misaligned V-belt drive will reduce belt life. Misaligned couplings place heavy loads on bearings which leads to their premature failure.
- ☐ 6. If blower is V-belt driven, check the belt tension. Over-tensioned belts create heavy bearing loads which lead to premature bearing failure.
- ☐ 7. If blower is V-belt driven, check for excessive overhung load condition. Loads in excess of maximum allowable overhung load limitations will lead to premature bearing failure and shaft breakage.
- ☐ 8. Be sure adequate drive guards are in place to protect the operator from SEVERE PERSONAL INJURY from contact with rotating components.
- ☐ 9. Turn the unit over by hand to be sure there is no binding or rotor contact. Special wear-in seals are utilized in DuroFlow blowers. When units are new, some resistance to turning the driveshaft by hand will be encountered. After several hours of running, this seal pressure will relieve itself and the blower will be somewhat easier to turn.
- ☐ 10. Jog the blower with the motor to check for proper rotation and airflow direction. Listen for unusual noise coming from the blower or motor and make sure the blower coasts smoothly to a stop.
- ☐ 11. Start unit and operate for 15 minutes with no load. Check for hot spots on housing or end plates, noise and other indications of interference. Allow the blower to cool to room temperature and re-check oil level. Add oil if necessary. DO NOT OVERFILL.
- ☐ 12. Check to be certain that actual blower speed is within allowable limits.
- ☐ 13. Apply load and observe operation for the first hour, checking pressure and air discharge temperature:
 - (a) Do not operate blower over manufacturer's specified pressure or vacuum rating.
 - (b) Discharge air temperature should not exceed the maximum allowable temperature.
- ☐ 14. Check and retension belts after the first few hours of operation to minimize slippage and belt wear. DO NOT OVERTENSION.
- ☐ 15. If mechanical problems are encountered during installation or start-up, notify your nearest DuroFlow Distributor. Never continue to operate your DuroFlow blower if you detect a malfunction, as serious damage can occur. Do not attempt any internal investigation without factory authorization since this will void the warranty.

SECTION 5 MAINTENANCE AND TROUBLESHOOTING

Your DuroFlow blower has been designed, manufactured and tested to precise specifications. Every DuroFlow blower is backed by over 70 years of proven performance in the most demanding applications that modern industry can produce. DuroFlow blowers have been designed specifically for long, trouble-free service. Minimal maintenance is required to keep your DuroFlow blower in top operating condition. Your attention to the following key points will insure years of dependable DuroFlow blower performance.

Key Points for Long Blower Life

1. Use AEON PD Synthetic Blower Lubricant to assure maximum blower protection.
2. The oil level must be checked periodically.
3. Drain and refill the blower with fresh AEON PD every 2000 hours of operation, 500 hours if using mineral based lubricant.
4. Clean the breather filters at every oil change or more often if dust conditions are severe.
5. Service the intake and in-line filters regularly to make sure that air flow restriction does not occur and that foreign material does not enter the blower.
6. If the blower is taken out of service for any reason, be sure to protect all interior surfaces from rusting.

TRUBLE SHOOTING

No matter how well the equipment is designed and manufactured, there may be times when servicing will be required due to normal wear, the need for adjustment, or various external causes. Whenever equip-

ment needs attention, the operator or service technician should be able to locate the cause and correct the trouble quickly by following the Troubleshooting Chart given below:

| PROBLEM | POSSIBLE CAUSES | SOLUTION |
|--|--|---|
| Knocking and excessive mechanical noise. | <ol style="list-style-type: none"> 1. Unit out of time. 2. Distortion due to improper mounting or pipe strains. 3. Excessive pressure differential. 4. Worn gears. 5. Worn bearings. | <ol style="list-style-type: none"> 1. Retime rotors. (See page 17.) 2. Check mounting alignment and relieve pipe strains. 3. Reduce to manufacturer's recommended pressure or vacuum. Examine relief valve, re-set if necessary. 4. Replace timing gears. (See page 17.) 5. Replace bearings. (See page 17.) |
| Excessive blower temperature. | <ol style="list-style-type: none"> 1. Too much oil in gear case. 2. Too low operating speed. 3. Plugged filter or silencer. 4. Excessive pressure differential. 5. Worn rotors clearances. 6. Internal contact. 7. Excessive inlet temperature. | <ol style="list-style-type: none"> 1. Reduce oil level. 2. Increase blower speed. Check sheave set 3. Remove cause of obstruction. 4. Reduce pressure differential across the blower. 5. Replace rotors. (See page 17.) 6. Correct clearances. (See page 17.) 7. Relocate intake to cooler area. |

| PROBLEM | POSSIBLE CAUSES | SOLUTION |
|---|--|---|
| Rotor contact with housing or endplate. | <ol style="list-style-type: none"> 1. Insufficient assembled clearances. 2. Case or frame distortion. 3. Excessive operating pressure. 4. Excessive operating temperature. 5. Material ingestion through the blower. | <ol style="list-style-type: none"> 1. Return for Warranty. (See page 17.) 2. Remove all mounting and pipe strains. 3. Remove cause. 4. Remove cause. 5. Replace worn inlet and inline filters. Install check valve between blower and first material load point to eliminate blow-back when blower is stopped. |
| Lack of CFM delivery. | <ol style="list-style-type: none"> 1. Slipping belts. 2. Worn clearances. 3. Blower RPM too slow. | <ol style="list-style-type: none"> 1. Tighten belts. 2. Replace rotors. (See page 17.) 3. Increase Blower speed. Check sheave set. |
| Excessive bearing or gear wear. | <ol style="list-style-type: none"> 1. Improper lubrication. 2. Oversized belt drive, over-tightened belts. | <ol style="list-style-type: none"> 1. Correct lubrication level. Replace dirty oil with AEON PD Synthetic Blower Lubricant. 2. Re-tension belts to proper tightness. Check drive to eliminate possible overhung load condition. |
| Loss of oil from seal vents. | <ol style="list-style-type: none"> 1. Worn oil seal. 2. Damaged seal sleeve. 3. Gear case or drive cover breathers plugged. | <ol style="list-style-type: none"> 1. Replace seals. (See page 17.) 2. Replace sleeve. (See page 17.) 3. Clean breather filters. |
| Loss of oil from breather filters. | <ol style="list-style-type: none"> 1. Endplate seal vents plugged. 2. Worn oil seal. | <ol style="list-style-type: none"> 1. Clean vents of obstruction. Do not plug seal vents. 2. Replace seals. (See page 17.) |
| Loss of oil from driveshaft seal. | <ol style="list-style-type: none"> 1. Worn oil seal. 2. Damaged seal sleeve. | <ol style="list-style-type: none"> 1. Replace seal. (See page 17.) 2. Replace sleeve. (See page 17.) |
| Excessive vibration. | <ol style="list-style-type: none"> 1. Inadequate package design. 2. Soft foot. 3. Material build-up inside rotors. 4. Bearing failure. 5. Excessive gear wear. 6. Bent shaft. 7. Internal mechanical contact. | <ol style="list-style-type: none"> 1. Reinstall base – fill with concrete. 2. Shim to eliminate condition. 3. Replace worn inlet and inline filters. Install check valve between blower and first material load point to eliminate blow-back when blower is stopped 4. Replace bearings. 5. Replace gears. 6. Replace rotor set. 7. See "Rotor Contact" above. |

If you are unable to resolve the problem, contact your DuroFlow Distributor for immediate assistance.

SECTION 6 SERVICE OPTIONS

Factory Remanufactured Blower Program

STOP

You have turned to the service section because you have a blower problem that requires the blower to be mechanically adjusted or repaired. First determine if the blower is still under warranty. Contact your DuroFlow Distributor and provide them with the blower SERIAL NUMBER located on the blower name plate. DuroFlow will promptly handle all warranty claims according to the warranty policy on page 28.

If the blower is out of warranty: The DuroFlow blower is a precision machine that requires special tools and experience to be properly repaired. Before you attempt any in-house repairs on a DuroFlow blower, we recommended that you first contact your authorized DuroFlow Distributor who is factory-trained and certified to perform the following services utilizing DuroFlow parts:

- Bearing and seal replacement
- Re-time rotors and set clearances

Clean-up following massive product ingestion

If your repair is more serious than the above procedures and involves the repair or replacement of a major blower component, you will benefit greatly by using the **DUROFLOW FACTORY REMANUFACTURED BLOWER EXCHANGE PROGRAM**. See page i for additional information.

LOOK

Look how easy it is to use the DuroFlow factory remanufactured blower program:

1. The moment you detect a major problem, simply contact your DuroFlow Distributor to order your factory remanufactured DuroFlow blower. You only need to supply the blower serial number and model number which are listed on the blower nameplate.
2. Your distributor will immediately ship a factory remanufactured blower from its inventory directly to your attention. Factory remanufactured DuroFlow blowers are backed by a full, new blower warranty . . . 18 months from the date of shipment or 12 months in service, whichever occurs first, and each remanufactured blower incorporates all

of the latest design technology and enhancements.

3. When you install your remanufactured DuroFlow unit, simply return the failed blower . . . freight collect . . . to our Indianapolis, IN Remanufacturing Center for a core credit. Your total cost for a factory remanufactured blower, after core credit, is significantly less than a new machine.

NOTICE

Inlet and discharge connectors are reusable. Remove connectors from the failed blower before returning the core to the Indianapolis, IN Remanufacturing Center.

LISTEN

Listen to the sound of your well running plant, not the complaints of your exasperated mechanics when they realize that properly repairing a DuroFlow blower is a much more delicate and difficult process than it originally appeared to be. Listen to the experience of thousands of plant operators who depend upon the DuroFlow remanufactured blower program to save them time, money and frustration. Remember, every DuroFlow factory remanufactured blower is backed with a full new blower warranty – 18 months from the date of shipment or 12 months from the date of start-up, whichever occurs first.

Repair Parts

If you elect to attempt a repair on your DuroFlow blower make certain you **use genuine DuroFlow original equipment parts** to retain the performance and dependability of your DuroFlow blower.

Factory genuine parts, engineered to original tolerances, are designed for optimum dependability . . . specifically for your blower. Design and material innovations are born from years of experience with hundreds of different blower applications. When you specify factory genuine parts you are assured of receiving parts that incorporate the most current design advances.

ments . . . manufactured in our state-of-the-art blower factory under exacting quality standards.

Prepackaged overhaul kits are available for immediate shipment for all DuroFlow blowers. Kits include all the normal wearing parts needed to overhaul your DuroFlow blower: Oil seals, air seals, bearings, spacers, gaskets, and Belleville timing spring. Part numbers for overhaul kits are given below.

Refer to Section 7 for additional part numbers as required.

Parts Ordering Instructions

When ordering parts, indicate the model and serial number from the blower nameplate and identify the blower configuration by referring to Figure 1-3, page 6.

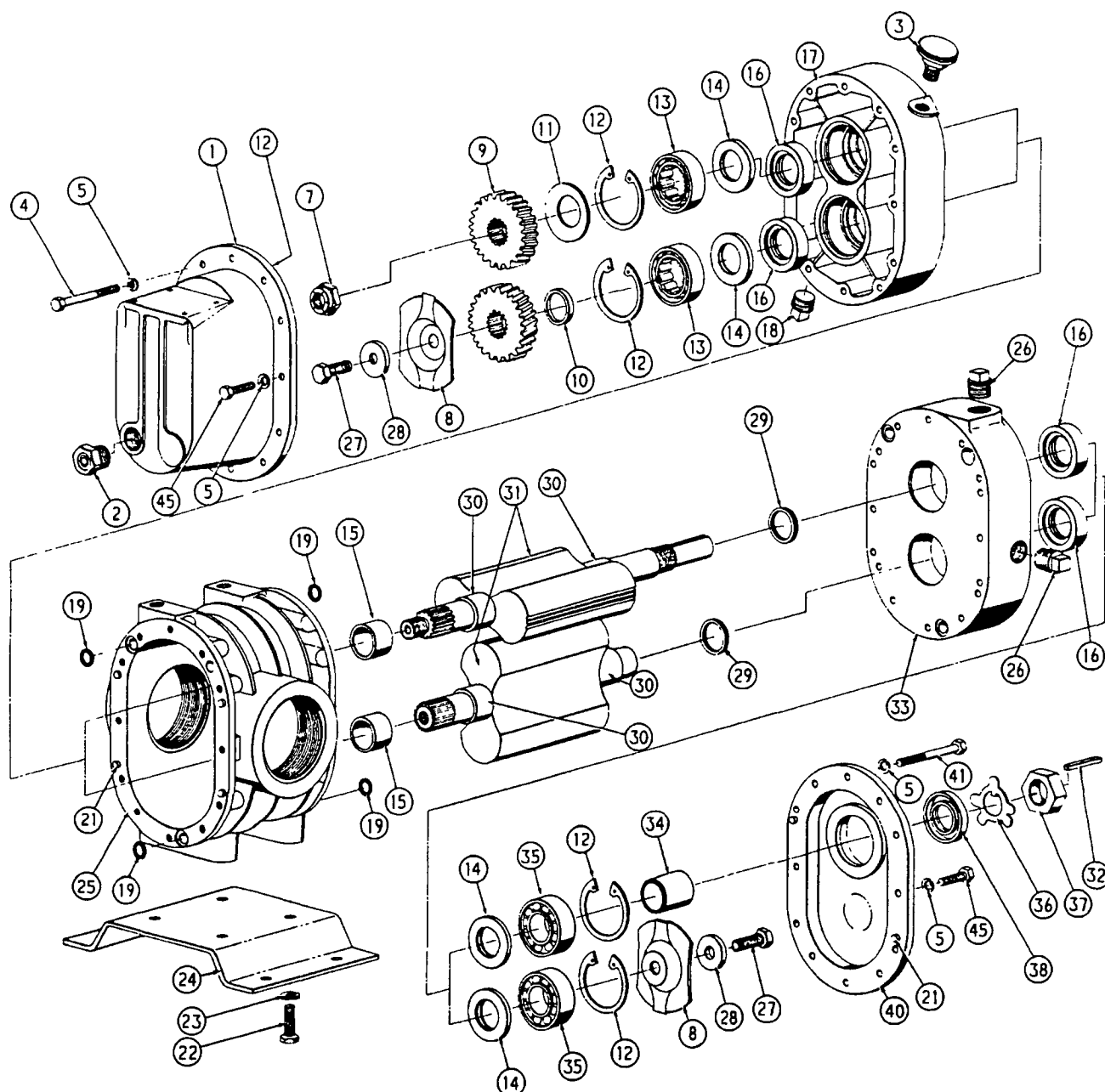
For prompt, professional assistance in selecting the correct repair parts for your DuroFlow blower, contact your Duroflow Distributor who maintains a large inventory of genuine DuroFlow parts. If you do not know your DuroFlow Distributor, contact:

DuroFlow Customer Service – (217) 224-8800.

| OVERHAUL KITS | |
|---------------------------------------|-------------|
| Model | Part Number |
| 30 Series Overhaul Kit | |
| All Models with 1-Piece Housing | 200GGB6010 |
| All Models with 2-Piece Housing | DF147400 |
| 45 Series Overhaul Kit | |
| 4504 Model | 203GGD6010 |
| 4506 Model | 202GGD6010 |
| 4509 Model | 201GGD6010 |
| 4512 Model | 200GGD6010 |
| 4518 Model | 204GGD6010 |
| 70 Series Overhaul Kit | |
| All Models | 200GGG6010 |

SECTION 7 PARTS LISTS AND EXPLODED VIEWS

30 SERIES DUROFLOW BLOWER EXPLODED VIEW



**200GGB810
(Ref. Drawing)**

Order by Part Number and Description. Reference Numbers are for your convenience only.

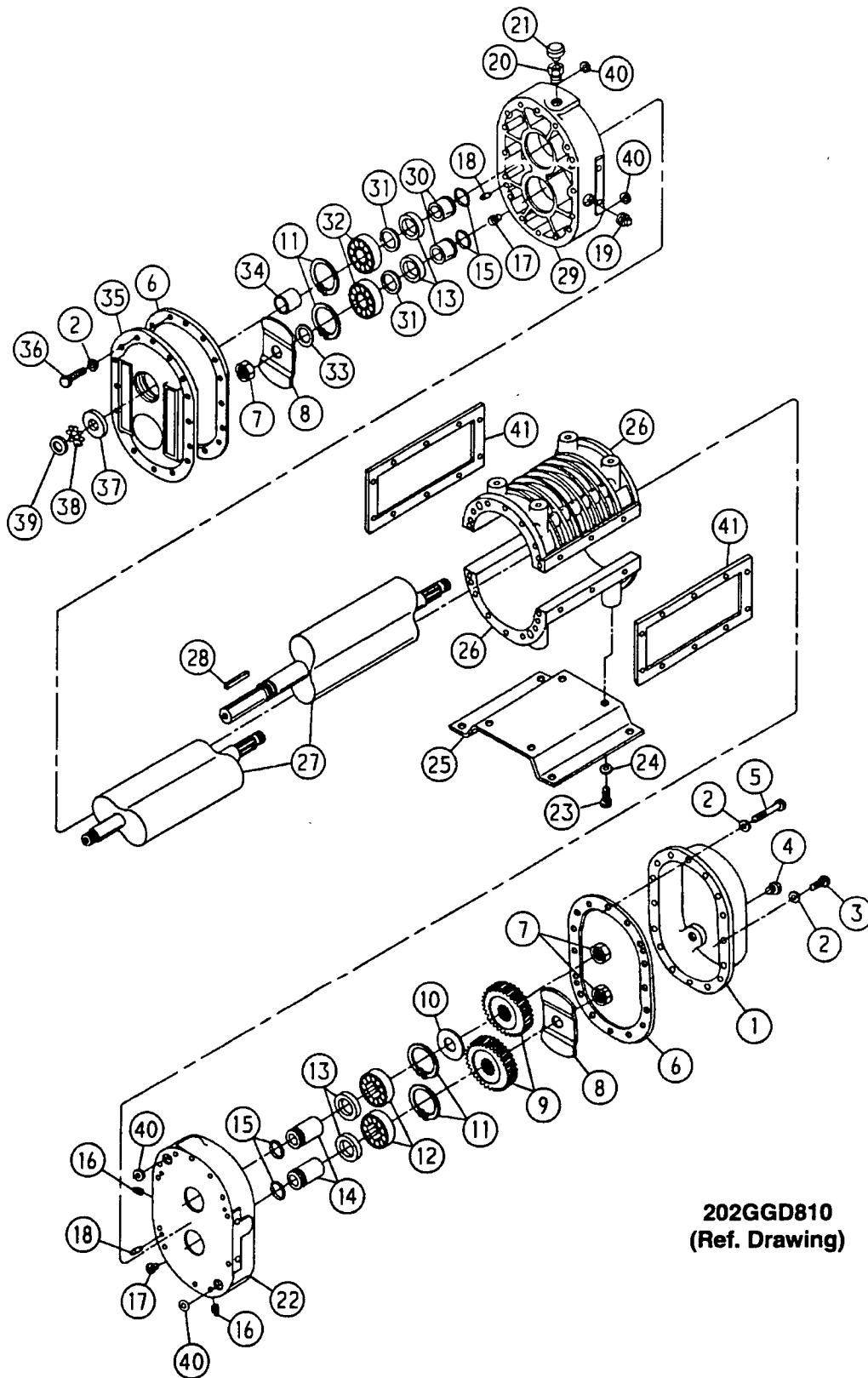
| Ref. No. | Name of Part. | | Size 3004 GGBA_B_ Part No. | Size 3006 GGBB_B_ Part No. |
|-------------|---------------------------|----|-------------------------------------|-------------------------------------|
| 1 | COVER-GEAR | 1 | DF145949 | DF145949 |
| 2 | GAUGE-SIGHT | 1 | 40L16 | 40L16 |
| 3 | BREATHER | 1 | DF140867 | DF140867 |
| 4 | SCREW | 10 | 75A200 | 75A200 |
| 5 | WASHER-LOCK | 24 | 95B2 | 95B2 |
| * 6 | GASKET | 2 | DF146038 | DF146038 |
| 7 | LOCKNUT | 1 | 50AH9 | 50AH9 |
| ** 8 | FLINGER | 2 | DF181216 | DF181216 |
| 9 | KIT-GEAR | 1 | 200GGB6008 | 200GGB6008 |
| 10 | SPACER-BEARING | 1 | DF182629 | DF182629 |
| * 11 | SPRING-BELLEVILLE | 1 | DF181206 | DF181206 |
| 12 | RING RETAINER | 4 | 74D68 | 74D68 |
| * 13 | BEARING-ROLLER | 2 | DF127253 | DF127253 |
| * 14 | SEAL-OIL | 4 | DF181201 | DF181201 |
| 15 | BEARING SLEEVE | 2 | DF139787 | DF139787 |
| * 16 | SEAL-LABYRINTH | 4 | DF184836 | DF184836 |
| 17 | END PLATE-GEAR END | 1 | DF184563 | DF184563 |
| 18 | PLUG | 2 | 64AA4 | 64AA4 |
| * 19 | SEAL RING | 4 | DF185304 | DF185304 |
| *** 20 | BREATHER VENT | 2 | DF186545 | DF186545 |
| 21 | DOWEL | 6 | DF119279 | DF119279 |
| 22 | SCREW | 4 | 655EE040 | 655EE040 |
| 23 | WASHER-LOCK | 4 | 95B5 | 95B5 |
| 24 | PLATE-VERT MTG | 1 | DF140824 | 200GGB247 |
| *** 25 | BRACKET-HORIZ MTG | 2 | DF193167 | DF193167 |
| 26 | CYLINDER | 1 | DF184565 | DF184593 |
| 27 | PLUG | 2 | 64A24 | 64A24 |
| 28 | SCREW | 2 | 655EE04N | 655EE04N |
| 29 | WASHER (SPECIAL) | 2 | DF181207 | DF181207 |
| * 30 | SHIM SET | 2 | 200GGB732 | 200GGB732 |
| 31 | SLEEVE | 4 | DF184679 | DF184679 |
| 32 | GRP-ROTOR | 1 | 203GGB4028 | 204GGB4028 |
| 33 | KEY | 1 | DF140890 | DF140890 |
| 34 | END PLATE-DRIVE END | 1 | DF184564 | DF184564 |
| 35 | SPACER-BEARING | 1 | DF135837 | DF135837 |
| * 36 | BEARING-BALL | 2 | DF138454 | DF138454 |
| * 37 | WASHER-LOCKING | 1 | DF140892 | DF140892 |
| * 38 | JAM NUT-SPECIAL | 1 | DF140891 | DF140891 |
| * 40 | SEAL-OIL | 1 | DF139790 | DF139790 |
| 41 | COVER-DRIVE END | 1 | DF135807 | DF135807 |
| 46 | SCREW | 10 | 75A248 | 75A248 |
| 47 | SCREW | 4 | 75A10 | 75A10 |
| *** 47 | LUG-LIFTING | 2 | 200GAA451 | 200GAA451 |
| ** | KIT-OVERHAUL | 0 | 200GGB6010 | 200GGB6010 |

* Included in Overhaul Kit

** No. Req'd. and Part No. for Vertical Top and Horizontal Right hand shaft locations, for optional Vertical Bottom and Horizontal Left hand shaft locations No. Req'd. becomes (1) DF182820 and qty (1) DF143399 Flinger is added to drive end.

*** Not shown on illustration.

**45 SERIES DUROFLOW BLOWER
EXPLODED VIEW**



Order by Part Number and Description. Reference Numbers are for your convenience only.

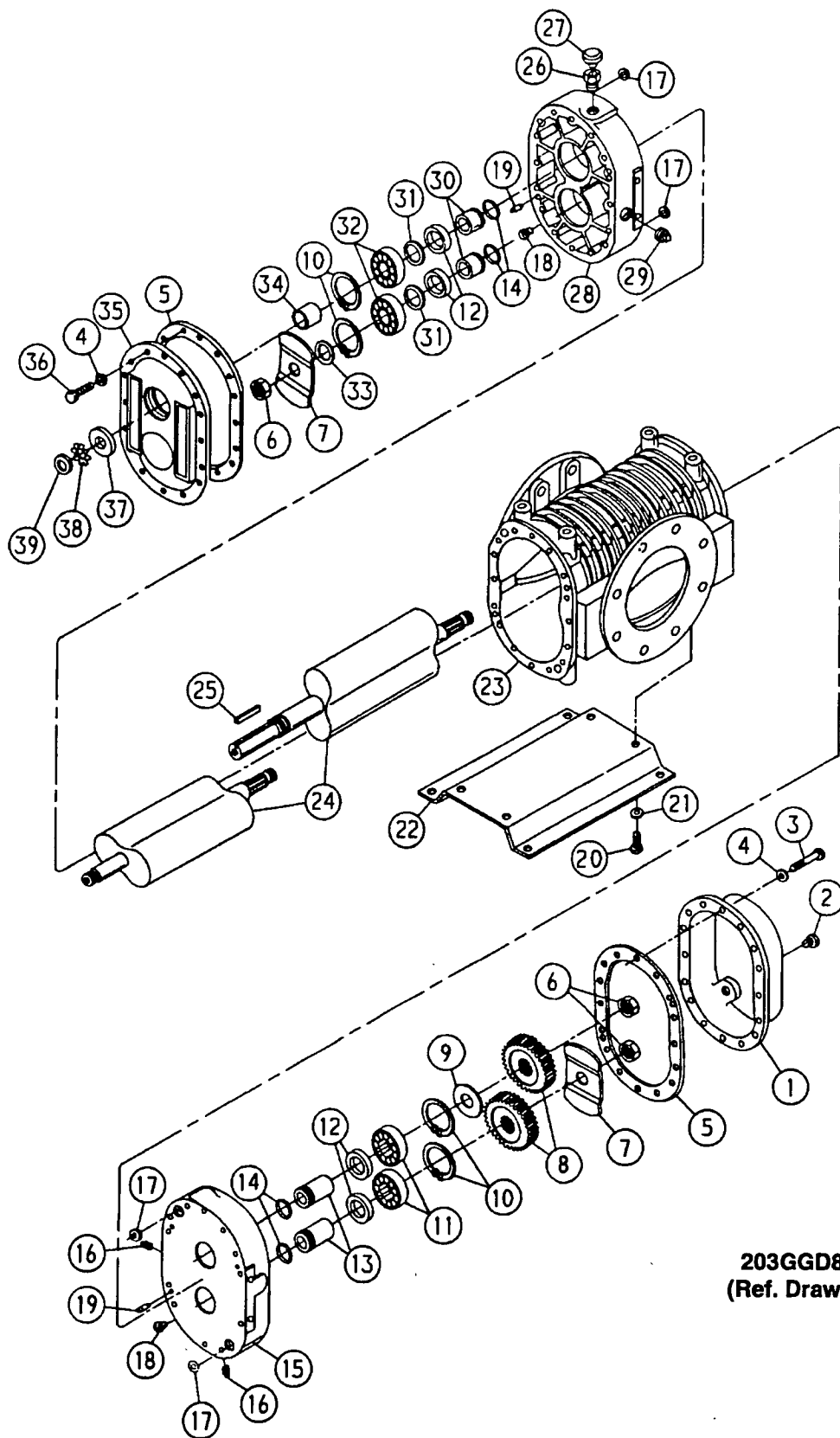
| Ref. No. | Name of Part. | | Size 4504 GGDA_B_ Part No. | Size 4506 GGDB_B_ Part No.. | Size 4509 GGDC_B_ Part No. | Size 4512 GGDD_B_ Part No. |
|-------------|--------------------------|----|-------------------------------------|--------------------------------------|-------------------------------------|-------------------------------------|
| 1 | COVER-GEAR | 1 | 200GGD602 | 200GGD602 | 200GGD602 | 200GGD602 |
| 2 | WASHER-LOCK | 32 | 95B3 | 95B3 | 95B3 | 95B3 |
| 3 | SCREW-HX HD CAP | 4 | 655ED040 | 655ED040 | 655ED040 | 655ED040 |
| 4 | GLASS-SIGHT | 1 | DF137799 | DF137799 | DF137799 | DF137799 |
| 5 | SCREW-HX HD CAP | 14 | 655ED150 | 655ED150 | 655ED150 | 655ED150 |
| * 6 | GASKET | 2 | DF135715 | DF135715 | DF135715 | DF135715 |
| 7 | LOCKNUT | 3 | 50AH12 | 50AH12 | 50AH12 | 50AH12 |
| ** 8 | FLINGER | 2 | DF188536 | DF188536 | DF188536 | DF188536 |
| 9 | KIT-GEAR | 1 | 200GGD6008 | 200GGD6008 | 200GGD6008 | 200GGD6008 |
| * 10 | SPRING-BELLVILLE | 1 | DF181069 | DF181069 | DF181069 | DF181069 |
| 11 | RING-RETAINING | 4 | 74D77 | 74D77 | 74D77 | 74D77 |
| * 12 | BEARING | 2 | DF138113 | DF138113 | DF138113 | DF138113 |
| * 13 | SEAL-OIL | 4 | DF181200 | DF181200 | DF181200 | DF181200 |
| * 14 | SLEEVE-BRG | 2 | DF138100 | DF138100 | DF138100 | DF138100 |
| * 15 | RING-SEALING | 4 | DF139986 | DF139986 | DF139986 | DF139986 |
| 16 | PLUG-SQ HD | 2 | 64AA4 | 64AA4 | 64AA4 | 64AA4 |
| 17 | BREATHER VENT | 2 | DF186545 | DF186545 | DF186545 | DF186545 |
| 18 | PIN-DOWEL | 10 | DF121880 | DF121880 | DF121880 | DF121880 |
| 19 | PLUG-SQ HD | 1 | 64A25 | 64A25 | 64A25 | 64A25 |
| 20 | BUSHING-PIPE | 1 | 64E27 | 64E27 | 64E27 | 64E27 |
| 21 | BREATHER | 1 | DF140867 | DF140867 | DF140867 | DF140867 |
| 22 | ENDPLATE | 1 | DF180672 | DF180672 | DF180672 | DF180672 |
| 23 | SCREW-HX HD CAP | 4 | 655EE050 | 655EE050 | 655EE050 | 655EE050 |
| 24 | WASHER-LOCK | 4 | 95B5 | 95B5 | 95B5 | 95B5 |
| 25 | PLATE-MTG (VERT) | 1 | DF141541 | DF135442 | DF135436 | DF135405 |
| | BRACKET-MTG (HORZ) | 2 | DF193168 | DF193168 | DF193168 | DF137804 |
| 26 | GROUP-CYLINDER | 1 | 203GGD4042 | 202GGD4042 | 201GGD4042 | 200GGD4042 |
| 27 | GROUP-ROTOR | 1 | 220GGD4028 | 221GGD4028 | 222GGD4028 | 223GGD4028 |
| 28 | KEY-SQUARE | 1 | 118401 | 105515 | 105515 | 105515 |
| 29 | ENDPLATE | 1 | DF180673 | DF180673 | DF180673 | DF180673 |
| 30 | SPACER-BRG | 2 | DF134662 | DF134662 | DF134662 | DF134662 |
| * 31 | SHIM SET | 2 | 200GGD732 | 200GGD732 | 200GGD732 | 200GGD732 |
| * 32 | BEARING | 2 | DF138116 | DF138116 | DF138116 | DF138116 |
| 33 | WASHER | 1 | DF135766 | DF135766 | DF135766 | DF135766 |
| 34 | SPACER-BRG | 1 | DF134671 | DF134671 | DF134671 | DF134671 |
| 35 | COVER-DRIVE | 1 | 202GGD477 | 202GGD477 | 202GGD477 | 202GGD477 |
| 36 | SCREW-HX HD CAP | 14 | 655ED170 | 655ED170 | 655ED170 | 655ED170 |
| * 37 | SEAL-OIL | 1 | DF134670 | DF134670 | DF134670 | DF134670 |
| * 38 | LOCKWASHER-BRG | 1 | 95N8 | 95N8 | 95N8 | 95N8 |
| * 39 | LOCKNUT-BRG | 1 | DF128040 | DF128040 | DF128040 | DF128040 |
| * 40 | SEAL RING | 4 | DF185304 | DF185304 | DF185304 | DF185304 |
| * 41 | GASKET | 2 | DF141539 | DF135718 | DF135717 | DF135716 |
| *** 52 | LUG-LIFTING | 2 | 201GAF451 | 201GAF451 | 201GAF451 | 201GAF451 |
| * 53 | KIT-OVERHAUL | 0 | 203GGD6010 | 202GGD6010 | 201GGD6010 | 200GGD6010 |

* Included in Overhaul Kit.

** No. Req'd. and Part No. for Vertical Top and Horizontal Left hand shaft locations, for optional Vertical Bottom and Horizontal Right hand shaft locations No. Req'd. becomes (1) and qty (1) DF143095 Slinger is added to drive end.

*** Not shown on illustration.

**45 SERIES DUROFLOW BLOWER
EXPLODED VIEW – MODEL 4518 BLOWER**



**203GGD810
(Ref. Drawing)**

Order by Part Number and Description. Reference Numbers are for your convenience only.

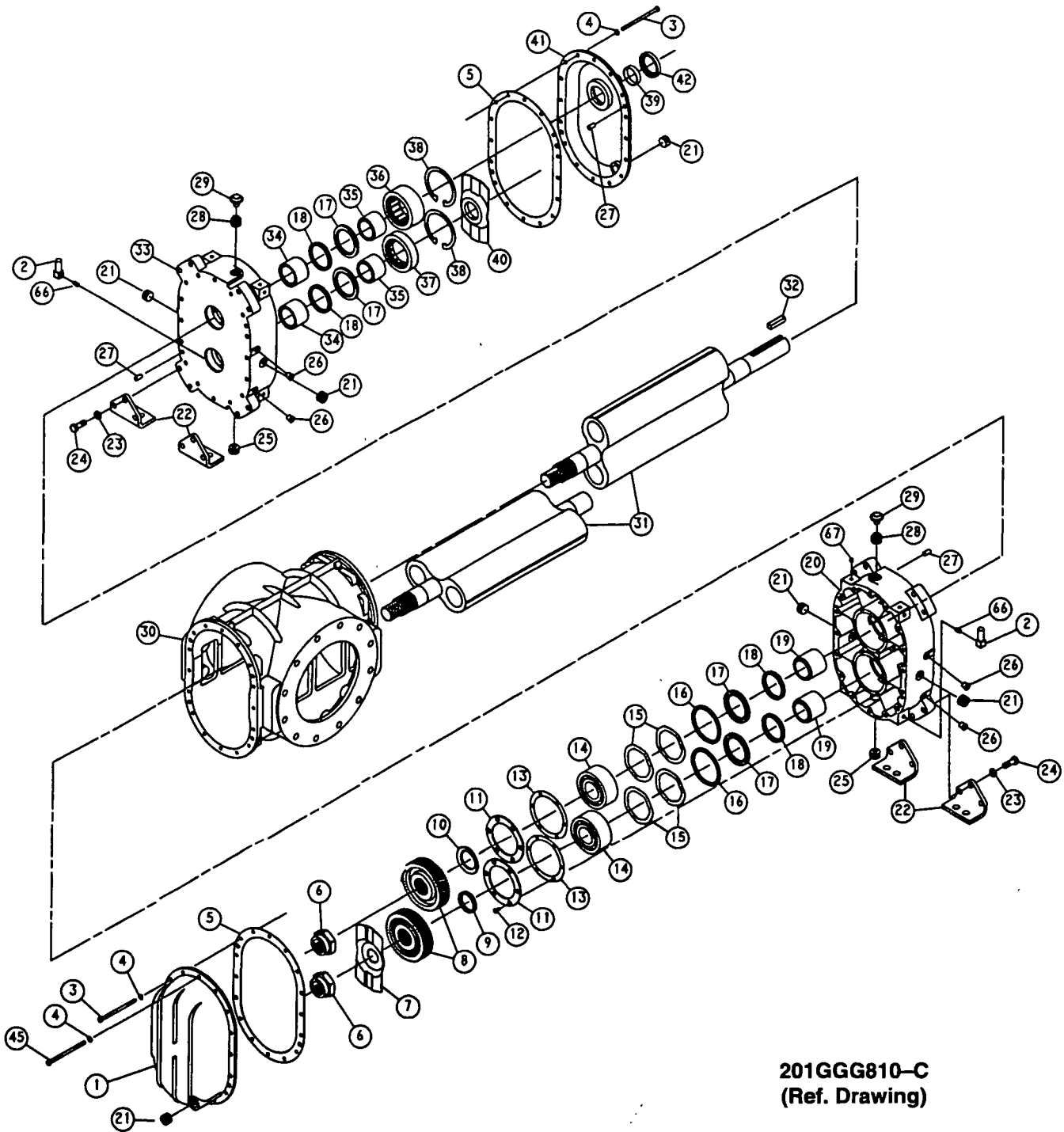
| Ref. No. | Name of Part. | Size 4518 GGDE_B_ Part No. |
|-------------|--------------------------|-------------------------------------|
| 1 | COVER-GEAR | 1 200GGD602 |
| 2 | GLASS-SIGHT | 1 DF137799 |
| 3 | SCREW-HX HD CAP | 16 655ED150 |
| 4 | WASHER-LOCK | 32 95B3 |
| * 5 | GASKET | 2 DF135715 |
| 6 | LOCKNUT | 3 50AH12 |
| ** 7 | FLINGER | 2 DF188536 |
| 8 | KIT-GEAR | 1 200GGD6008 |
| * 9 | SPRING-BELLVILLE | 1 DF181069 |
| 10 | RING-RETAINING | 4 74D77 |
| * 11 | BEARING | 2 DF138113 |
| * 12 | SEAL-OIL | 4 DF181200 |
| * 13 | SLEEVE-BRG | 2 DF138100 |
| * 14 | RING-SEALING | 4 DF139986 |
| 15 | ENDPLATE | 1 200GGD006 |
| 16 | PLUG-SQ HD | 2 64AA4 |
| * 17 | SEAL RING | 4 DF185304 |
| 18 | BREATHER VENT | 2 DF186545 |
| 19 | PIN-DOWEL | 6 DF121880 |
| 20 | SCREW-HX HD CAP | 4 655EE050 |
| 21 | WASHER-LOCK | 4 95B5 |
| 22 | BASE-MTG (VERT) | 1 200GGD285 |
| | BRACKET-MTG (HORZ) | 2 200GGD017 |
| 23 | CYLINDER | 1 201GGD002 |
| 24 | GROUP-ROTOR | 1 224GGD4028 |
| 25 | KEY-SQUARE | 1 105515 |
| 26 | BUSHING-PIPE | 1 64E27 |
| 27 | BREATHER | 1 DF140867 |
| 28 | ENDPLATE | 1 201GGD006 |
| 29 | PLUG-SQ HD | 1 64A25 |
| 30 | SPACER-BRG | 2 DF134662 |
| * 31 | SHIM SET | 2 200GGD732 |
| * 32 | BEARING | 2 DF138116 |
| 33 | WASHER | 1 DF135766 |
| 34 | SPACER-BRG | 1 DF134671 |
| 35 | COVER-DRIVE | 1 202GGD477 |
| 36 | SCREW-HX HD CAP | 16 655ED170 |
| * 37 | SEAL-OIL | 1 DF134670 |
| * 38 | LOCKWASHER-BRG | 1 95N8 |
| * 39 | LOCKNUT-BRG | 1 DF128040 |
| *** 52 | LUG-LIFTING | 2 201GAF451 |
| * 53 | KIT-OVERHAUL | 0 204GGD6010 |

* Included in Overhaul Kit.

** No. Req'd and Part No. for Vertical Top and Horizontal Left hand shaft locations, for optional Vertical Bottom and Horizontal Right hand shaft locations No. Req'd becomes (1) and qty (1) DF143095 Slinger is added to drive end.

*** Not shown on illustration.

**70 SERIES DUROFLOW BLOWER
EXPLODED VIEW**



Order by Part Number and Description. Reference Numbers are for your convenience only.

| Ref. No. | Name of Part. | | Size 7009 GGGA_C_ Part No. | Size 7012 GGGB_C_ Part No. | Size 7015 GGGC_C_ Part No. |
|-------------|---------------------------|----|-------------------------------------|-------------------------------------|-------------------------------------|
| 1 | COVER-GEAR | 1 | DF184015 | DF184015 | DF184015 |
| 2 | GLASS-SIGHT | 2 | 40P47 | 40P47 | 40P47 |
| 3 | SCREW-HX HD CAP | 32 | 655ED260 | 655ED260 | 655ED260 |
| 4 | WASHER-LOCK | 32 | 95B3 | 95B3 | 95B3 |
| * 5 | GASKET | 2 | DF184031 | DF184031 | DF184031 |
| 6 | NUT-HEX LOCK | 2 | DF184086 | DF184086 | DF184086 |
| 7 | FLINGER | 1 | DF184024 | DF184024 | DF184024 |
| 8 | KIT-GEAR | 1 | 200GGG6008 | 200GGG6008 | 200GGG6008 |
| 9 | SPACER | 1 | DF184028 | DF184028 | DF184028 |
| * 10 | SPRING-BELLVILLE | 1 | DF184030 | DF184030 | DF184030 |
| 11 | RETAINER-BRG | 2 | DF184019 | DF184019 | DF184019 |
| 12 | SCREW-HX SOC FLT HD | 12 | 75LM214 | 75LM214 | 75LM214 |
| * 13 | SHIM SET | 2 | 200GGG732 | 200GGG732 | 200GGG732 |
| * 14 | BEARING-BALL | 2 | DF184085 | DF184085 | DF184085 |
| 15 | WASHER-WAVY SPRING | 4 | 8508481 | 8508481 | 8508481 |
| 16 | SPACER-BRG | 2 | DF185556 | DF185556 | DF185556 |
| * 17 | SEAL-OIL | 4 | DF184084 | DF184084 | DF184084 |
| * 18 | SEAL-LABYRINTH | 4 | DF184838 | DF184838 | DF184838 |
| + 19 | SPACER (GEAR END) | 2 | DF189049 | DF189049 | DF189049 |
| 20 | HOUSING-BEARING | 1 | 301GGG006 | 301GGG006 | 301GGG006 |
| 21 | PLUG-CS HD | 6 | 64B4 | 64B4 | 64B4 |
| 22 | PLATE-MTG | 4 | DF184949 | DF184949 | DF184949 |
| 23 | WASHER-LOCK | 8 | 95B7 | 95B7 | 95B7 |
| 24 | SCREW-HX HD CAP | 8 | 655EF070 | 655EF070 | 655EF070 |
| 25 | PLUG-MAGNETIC | 2 | 64BJ7 | 64BJ7 | 64BJ7 |
| 26 | BREATHER VENT | 4 | DF186545 | DF186545 | DF186545 |
| 27 | PIN-DOWEL | 6 | 62M82 | 62M82 | 62M82 |
| 28 | BUSHING-PIPE | 2 | 64E27 | 64E27 | 64E27 |
| 29 | BREATHER | 2 | DF140867 | DF140867 | DF140867 |
| 30 | CYLINDER | 1 | DF189510 | DF189511 | DF189512 |
| 31 | GROUP-ROTOR | 1 | 206GGG4028 | 207GGG4028 | 208GGG4028 |
| 32 | KEY-SQUARE | 1 | 2800T17 | 2800T17 | 2800T17 |
| 33 | HOUSING-BEARING | 1 | 300GGG006 | 300GGG006 | 300GGG006 |
| + 34 | SPACER (DRIVE END) | 2 | DF189050 | DF189050 | DF189050 |
| *+ 35 | BEARING-INNER RACE | 2 | DF194012 | DF194012 | DF194012 |
| * 36 | BEARING-ROLLER | 1 | DF194014 | DF194014 | DF194014 |
| * 37 | BEARING-ROLLER | 1 | DF194011 | DF194011 | DF194011 |
| 38 | RING-RETAINING | 2 | 74D83 | 74D83 | 74D83 |
| * 39 | SLEEVE-WEAR | 1 | 80L6 | 80L6 | 80L6 |
| 40 | FLINGER ASM | 1 | DF189541 | DF189541 | DF189541 |
| ** 41 | COVER-DRIVE | 1 | DF191444 | DF191444 | DF191444 |
| * 42 | SEAL-OIL | 1 | DF191443 | DF191443 | DF191443 |
| *** 53 | LUG-LIFTING | 2 | 201GAF451 | 201GAF451 | 201GAF451 |
| 66 | NIPPLE | 2 | 63C4G | 63C4G | 63C4G |
| 67 | PLUG | 14 | 64B14 | 64B14 | 64B14 |
| * 68 | KIT-OVERHAUL | 0 | 200GGG6010 | 200GGG6010 | 200GGG6010 |

* Included in Overhaul Kit.

** For Vertical Top and Horizontal Left hand shaft locations, for optional Vertical Bottom and Horizontal Right hand shaft locations use Part No. DF191446.

*** Not shown on illustration.

+ Included with Group-Rotor - Ref. No. 31.

Order by Part Number and Description. Reference Numbers are for your convenience only.

| Ref. N . | Name of Part. | | Size 7018 GGGD_C_ Part No. | Size 7023 GGGE_C_ Part No. | Size 7028 GGGF_C_ Part No. |
|-------------|---------------------------|----|-------------------------------------|-------------------------------------|-------------------------------------|
| 1 | COVER-GEAR | 1 | DF184015 | DF184015 | DF184015 |
| 2 | GLASS-SIGHT | 2 | 40P47 | 40P47 | 40P47 |
| 3 | SCREW-HX HD CAP | 32 | 655ED260 | 655ED260 | 655ED260 |
| 4 | WASHER-LOCK | 32 | 95B3 | 95B3 | 95B3 |
| * 5 | GASKET | 2 | DF184031 | DF184031 | DF184031 |
| 6 | NUT-HEX LOCK | 2 | DF184086 | DF184086 | DF184086 |
| 7 | FLINGER | 1 | DF184024 | DF184024 | DF184024 |
| 8 | KIT-GEAR | 1 | 200GGG6008 | 200GGG6008 | 200GGG6008 |
| 9 | SPACER | 1 | DF184028 | DF184028 | DF184028 |
| * 10 | SPRING-BELLVILLE | 1 | DF184030 | DF184030 | DF184030 |
| 11 | RETAINER-BRG | 2 | DF184019 | DF184019 | DF184019 |
| 12 | SCREW-HX SOC FLT HD | 12 | 75LM214 | 75LM214 | 75LM214 |
| * 13 | SHIM SET | 2 | 200GGG732 | 200GGG732 | 200GGG732 |
| * 14 | BEARING-BALL | 2 | DF184085 | DF184085 | DF184085 |
| 15 | WASHER-WAVY SPRING | 4 | 8508481 | 8508481 | 8508481 |
| 16 | SPACER-BRG | 2 | DF185556 | DF185556 | DF185556 |
| * 17 | SEAL-OIL | 4 | DF184084 | DF184084 | DF184084 |
| * 18 | SEAL-LABYRINTH | 4 | DF184838 | DF184838 | DF184838 |
| + 19 | SPACER (GEAR END) | 2 | DF189049 | DF189049 | DF189049 |
| 20 | HOUSING-BEARING | 1 | 301GGG006 | 301GGG006 | 301GGG006 |
| 21 | PLUG-CS HD | 6 | 64B4 | 64B4 | 64B4 |
| 22 | PLATE-MTG | 4 | DF184949 | DF184949 | DF184949 |
| 23 | WASHER-LOCK | 8 | 95B7 | 95B7 | 95B7 |
| 24 | SCREW-HX HD CAP | 8 | 655EF070 | 655EF070 | 655EF070 |
| 25 | PLUG-MAGNETIC | 2 | 64BJ7 | 64BJ7 | 64BJ7 |
| 26 | BREATHER VENT | 4 | DF186545 | DF186545 | DF186545 |
| 27 | PIN-DOWEL | 6 | 62M82 | 62M82 | 62M82 |
| 28 | BUSHING-PIPE | 2 | 64E27 | 64E27 | 64E27 |
| 29 | BREATHER | 2 | DF140867 | DF140867 | DF140867 |
| 30 | CYLINDER | 1 | DF189513 | 201GGG002 | 200GGG002 |
| 31 | GROUP-ROTOR | 1 | 209GGG4028 | 210GGG4028 | 211GGG4028 |
| 32 | KEY-SQUARE | 1 | 2800T17 | 2800T17 | 2800T17 |
| 33 | HOUSING-BEARING | 1 | 300GGG006 | 300GGG006 | 300GGG006 |
| + 34 | SPACER (DRIVE END) | 2 | DF189050 | DF189050 | DF189050 |
| *+ 35 | BEARING-INNER RACE | 2 | DF194012 | DF194012 | DF194012 |
| * 36 | BEARING-ROLLER | 1 | DF194014 | DF194014 | DF194014 |
| * 37 | BEARING-ROLLER | 1 | DF194011 | DF194011 | DF194011 |
| 38 | RING-RETAINING | 2 | 74D83 | 74D83 | 74D83 |
| * 39 | SLEEVE-WEAR | 1 | 80L6 | 80L6 | 80L6 |
| 40 | FLINGER ASM | 1 | DF189541 | DF189541 | DF189541 |
| ** 41 | COVER-DRIVE | 1 | DF191444 | DF191444 | DF191444 |
| * 42 | SEAL-OIL | 1 | DF191443 | DF191443 | DF191443 |
| *** 53 | LUG-LIFTING | 2 | 201GAF451 | 201GAF451 | 201GAF451 |
| 66 | NIPPLE | 2 | 63C4G | 63C4G | 63C4G |
| 67 | PLUG | 14 | 64B14 | 64B14 | 64B14 |
| * 68 | KIT-OVERHAUL | 0 | 200GGG6010 | 200GGG6010 | 200GGG6010 |

* Included in Overhaul Kit.

** For Vertical Top and Horizontal Left hand shaft locations, for optional Vertical Bottom and Horizontal Right hand shaft locations use Part No. DF191446.

*** Not shown on illustration.

+ Included with Group-Rotor - Ref. No. 31.

Gardner Denver

1800 GARDNER EXPRESSWAY
QUINCY, IL 62301
TEL: (217) 222-5400 • FAX: (217) 224-7814

WARRANTY

DUROFLOW BLOWERS

30 SERIES

45 SERIES

70 SERIES

GENERAL PROVISIONS AND LIMITATIONS

Gardner Denver Machinery Inc. (the "Company") warrants to each original retail purchaser ("Purchaser") of its new products from the Company or its authorized distributor that such products are, at the time of delivery to the Purchaser, made with good material and workmanship. No warranty is made with respect to:

1. Any product which has been repaired or altered in such a way, in the Company's judgment, as to affect the product adversely.
2. Any product which has, in the Company's judgment been subject to negligence, accident, improper storage, or improper installation or application.
3. Any product which has not been operated or maintained in accordance with normal practice and with the recommendations of the Company.
4. Components or accessories manufactured, warranted and serviced by others.
5. Any reconditioned or prior owned product.

Claims for items described in (4) above should be submitted directly to the manufacturer.

WARRANTY PERIOD

The Company's obligation under this warranty is limited to repairing or, at its option, replacing, during normal business hours at an authorized service facility of the Company, any part which in its judgment proved not to be as warranted within the applicable Warranty Period as follows.

BARE BLOWERS

Basic bare blowers, consisting of all parts within, are warranted for 12 months from date of initial use or 18 months from date of shipment to the first purchaser, whichever occurs first.

Any disassembly or partial disassembly of the blower, or failure to return the "unopened" blower per Company instructions, will be cause for denial of warranty.

OTHER COMPONENTS

All other components are warranted for 12 months from date of initial use or 18 months from date of shipment to first purchaser, whichever comes first.

LABOR TRANSPORTATION AND INSPECTION

The Company will provide labor, by Company representative or authorized service personnel, for repair or replacement of any product or part thereof which in the

Company's judgment is proved not to be as warranted. Labor shall be limited to the amount specified in the Company's labor rate schedule.

Labor costs in excess of the Company rate schedule amounts or labor provided by unauthorized service personnel is not provided for by this warranty.

All costs of transportation of product, labor or parts claimed not to be as warranted and, of repaired or replacement parts to or from such service facilities shall be borne by the Purchaser. The Company may require the return of any part claimed not to be as warranted to one of its facilities as designated by Company, transportation prepaid by Purchaser, to establish a claim under this warranty.

Replacement parts provided under the terms of the warranty are warranted for the remainder of the Warranty Period of the product upon which installed to the same extent as if such parts were original components thereof.

DISCLAIMER

THE FOREGOING WARRANTY IS EXCLUSIVE AND IT IS EXPRESSLY AGREED THAT, EXCEPT AS TO TITLE, THE COMPANY MAKES NO OTHER WARRANTIES, EXPRESSED, IMPLIED OR STATUTORY, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY.

THE REMEDY PROVIDED UNDER THIS WARRANTY SHALL BE THE SOLE, EXCLUSIVE AND ONLY REMEDY AVAILABLE TO PURCHASER AND IN NO CASE SHALL THE COMPANY BE SUBJECT TO ANY OTHER OBLIGATIONS OR LIABILITIES. UNDER NO CIRCUMSTANCES SHALL THE COMPANY BE LIABLE FOR SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES, EXPENSES, LOSSES OR DELAYS HOWSOEVER CAUSED.

No statement, representation, agreement, or understanding, oral or written, made by any agent, distributor, representative, or employee of the Company which is not contained in this Warranty will be binding upon the Company unless made in writing and executed by an officer of the Company.

This warranty shall not be effective as to any claim which is not presented within 30 days after the date upon which the product is claimed not to have been as warranted. Any action for breach of this warranty must be commenced within one year after the date upon which the cause of action occurred.

Any adjustment made pursuant to this warranty shall not be construed as an admission by the Company that any product was not as warranted.

Warranty Registration

Your DuroFlow blower has been designed and manufactured to provide continuous, trouble-free service, year in and year out.

Follow the simple maintenance procedures outlined in this manual and you will be assured of superior blower performance and years of dependable blower life.

Please register your DuroFlow Blower with our Factory Service & Warranty Department. Complete the warranty registration information below and fax it to Gardner Denver Machinery Inc. at the following number:

ATTENTION: BLOWER PRODUCT MARKETING

FAX: 217-228-8247

Thanks again for the privilege of serving you with quality from DuroFlow.

Date :

Your Name:

Your Title:

Your Company:

Address:

City, State, Zip:

Telephone:

Blower Serial Number:

Date of Blower Start-up:

What is your application:

Magnehelic® Differential Pressure Gage**Dwyer****SPECIFICATIONS**

Dimensions: 4-3/4" dia. X 2-3/16" deep.

Weight: 1 lb. 2 oz.

Finish: Baked dark gray enamel.

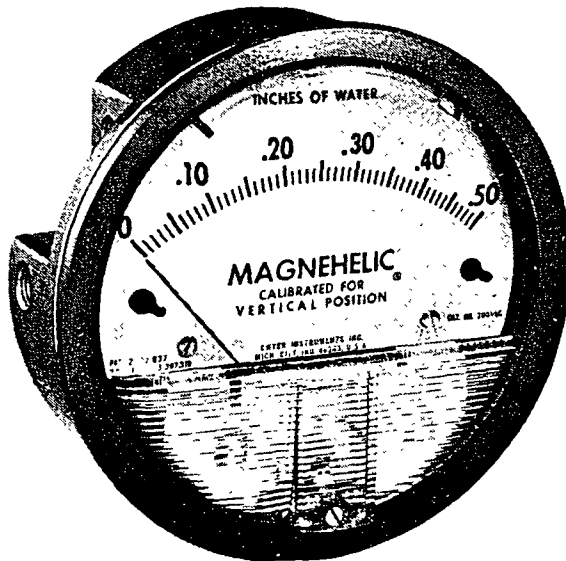
Connections: 1/8" N.P.T. high and low pressure taps, duplicated, one pair side and one pair back.

Accuracy: Plus or minus 2% of full scale, at 70°F.
(Model 2000-0, 3%; 2000-00, 4%).

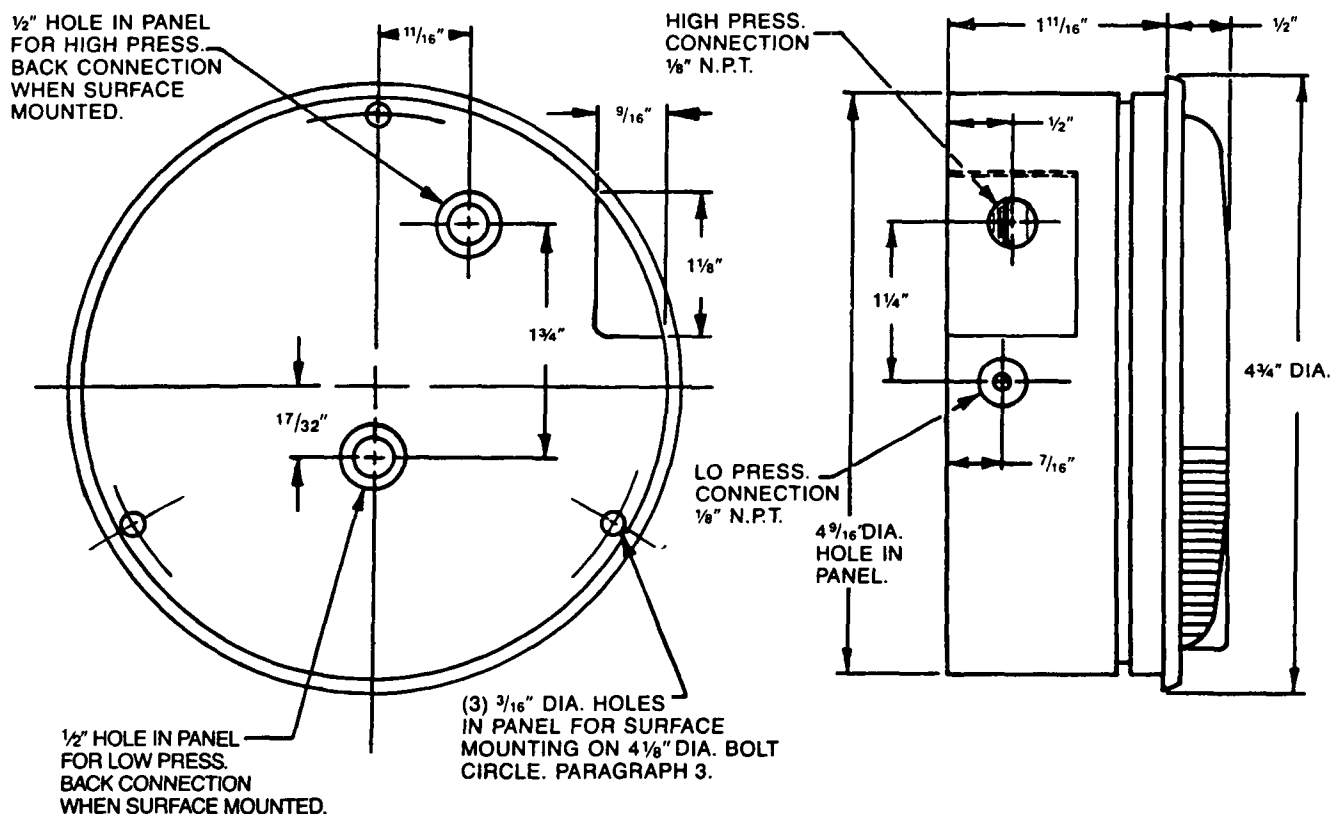
Pressure Rating: 15 PSI.

Ambient Temperature Range: 20° to 140°F.

Standard gage accessories include two 1/8" N.P.T. plugs for duplicate pressure taps, two 1/8" pipe thread to rubber tubing adapters, and three flush mounting adapters with screws.

**Caution:** For use with air or compatible gases only.

For repeated over-ranging or high cycle rates, contact factory.

Hydrogen Gas Precautionary Note: The rectangular rare earth magnet used in the standard gage may not be suitable for use with hydrogen gas since a toxic and explosive gas may form. For hydrogen service, consult the factory for an alternate gage construction.**DWYER INSTRUMENTS, INC.**

P. O. BOX 373 • MICHIGAN CITY, INDIANA 46360, U.S.A.

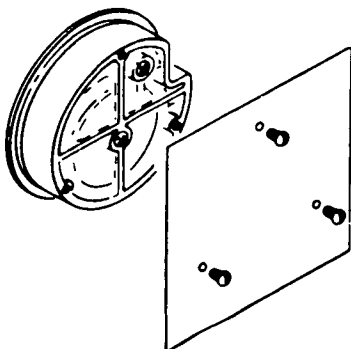
Telephone 219/879-8000
Fax 219/872-9057

MAGNEHELIC® INSTALLATION

1. Select a location free from excessive vibration and where the ambient temperature will not exceed 140°F. Also, avoid direct sunlight which accelerates discoloration of the clear plastic cover. Sensing lines may be run any necessary distance. Long tubing lengths will not affect accuracy but will increase response time slightly. Do not restrict lines. If pulsating pressures or vibration cause excessive pointer oscillation, consult the factory for ways to provide additional damping.

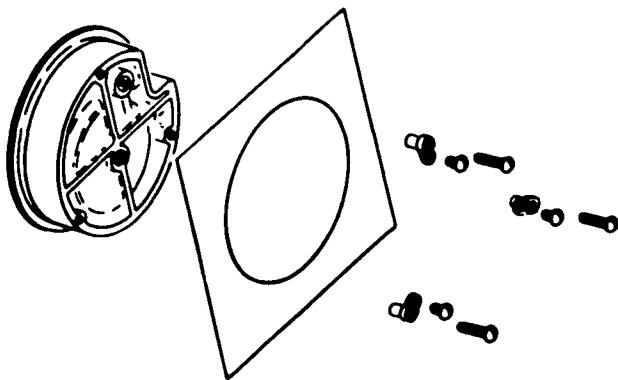
2. All standard Magnehelic gages are calibrated with the diaphragm vertical and should be used in that position for maximum accuracy. If gages are to be used in other than vertical position, this should be specified on the order. Many higher range gages will perform within tolerance in other positions with only rezeroing. Low range Model 2000-00 and metric equivalents must be used in the vertical position only.

3. Surface Mounting



Locate mounting holes, 120° apart on a 4-1/8" dia. circle. Use No. 6-32 machine screws of appropriate length.

4. Flush Mounting



Provide a 4 9/16" dia. opening in panel. Insert gage and secure in place with No. 6-32 machine screws of appropriate length, with adaptors, Part No. 360c, firmly secured in place. To mount gage on 1 1/4"-2" pipe, order optional A-610 pipe mounting kit.

5. To zero the gage after installation

Set the indicating pointer exactly on the zero mark, using the external zero adjust screw on the cover at the bottom. Note that the zero check or adjustment can only be made with the high and low pressure taps both open to atmosphere.

Operation

Positive Pressure: Connect tubing from source of pressure to either of the two high pressure ports. Plug the port not used. Vent one or both low pressure ports to atmosphere.

Negative Pressure: Connect tubing from source of vacuum or negative pressure to either of the two low pressure ports. Plug the port not used. Vent one or both high pressure ports to atmosphere.

Differential Pressure: Connect tubing from the greater of two pressure sources to either high pressure port and the lower to either low pressure port. Plug both unused ports.

When one side of gage is vented in a dirty, dusty atmosphere, we suggest an A-331 Filter Vent Plug be installed in the open port to keep inside of gage clean.

a. For portable use or temporary installation, use 1/8" pipe thread to rubber tubing adapter and connect to source of pressure with rubber or Tygon tubing.

b. For permanent installation, 1/4" O.D., or larger, copper or aluminum tubing is recommended. See accessory bulletin S-101 for fittings.

Maintenance: No lubrication or periodic servicing is required. Keep case exterior and cover clean. Occasionally disconnect pressure lines to vent both sides of gage to atmosphere and re-zero. Optional vent valves, (bulletin S-101), should be used in permanent installations.

Calibration Check: Select a second gage or manometer of known accuracy and in an appropriate range. Using short lengths of rubber or vinyl tubing, connect the high pressure side of the Magnehelic gage and the test gage to two legs of a tee. Very slowly apply pressure through the third leg. Allow a few seconds for pressure to equalize, fluid to drain, etc., and compare readings. If accuracy unacceptable, gage may be returned to factory for recalibration. To calibrate in the field, use the following procedure.

Calibration:

1. With gage case, P/N 1, held firmly, loosen bezel, P/N 4 by turning counter-clockwise. To avoid damage, a canvas strap wrench or similar tool should be used.
2. Lift out plastic cover and "O" ring.
3. Remove scale screws and scale assembly. Be careful not to damage pointer.
4. The calibration is changed by moving the clamp, P/N. 70-b. Loosen the clamp screw(s) and move slightly toward the helix if gage is reading high, and away if reading low. Tighten clamp screw and install scale assembly.
5. Place cover and O-ring in position. Make sure the hex shaft on inside of cover is properly engaged in zero adjust screw, P/N 230-b.
6. Secure cover in place by screwing bezel down snug. Note that the area under the cover is pressurized in operation and therefore gage will leak if not properly tightened.
7. Zero gage and compare to test instrument. Make further adjustments as necessary.

Caution: If bezel binds when installing, lubricate threads sparingly with light oil or molybdenum disulphide compound.

Warning: Attempted field repair may void your warranty. Recalibration or repair by the user is not recommended. For best results, return gage to the factory. Ship prepaid to:

Dwyer Instruments, Inc.
Attn. Repair Dept.
55 Ward St.
Wakarusa, IN 46573

Trouble Shooting Tips:

- *Gage won't indicate or is sluggish.*
 1. Duplicate pressure port not plugged.
 2. Diaphragm ruptured due to overpressure.
 3. Fittings or sensing lines blocked, pinched, or leaking.
 4. Cover loose or "O" ring damaged, missing.
 5. Pressure sensors, (static tips, Pitot tube, etc.) improperly located.
 6. Ambient temperature too low. For operation below 20°F, order gage with low temperature, (LT) option.
- *Pointer stuck-gage can't be zeroed.*
 1. Scale touching pointer.
 2. Spring/magnet assembly shifted and touching helix.
 3. Metallic particles clinging to magnet and interfering with helix movement.
 4. Cover zero adjust shaft broken or not properly engaged in P/N 230-b adjusting screw.

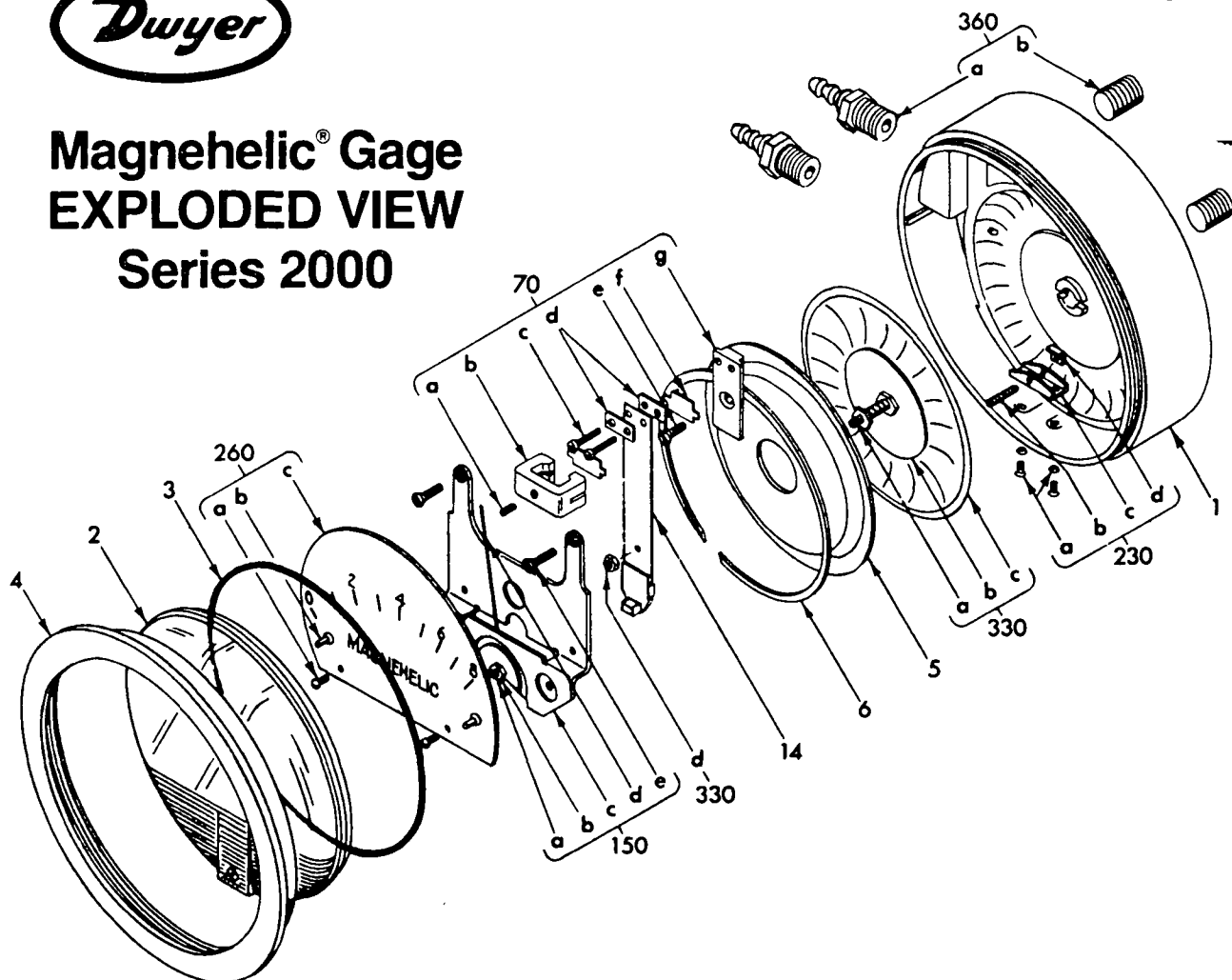
We generally recommend that gages needing repair be returned to the factory. Parts used in various sub-assemblies vary from one range of gage to another, and use of incorrect components may cause improper operation or failure. Gages repaired at the factory are carefully calibrated and tested to assure "like-new" operation. After receipt and inspection, we will be happy to quote repair costs before proceeding.

Consult factory for assistance on unusual applications or conditions.

Use with air or compatible gases only.



Magnehelic® Gage EXPLODED VIEW Series 2000



- 1. Case
- 2. Cover with zero adjust assy.
- 3. "O" ring seal
- 4. Bezel
- 5. Diaphragm sealing plate
- 6. Retaining ring
- 70. Range Spring assembly
 - a. Clamp set screw
 - b. Clamp
 - c. Mounting screws (2 req'd)
 - d. Clamping shoe (2 req'd)
 - e. Clamp plate screw
 - f. Spacer (2 req'd)
 - g. Clamp plate
- 14. Range Spring with magnet
- 150. Wishbone Assembly—consists of:
 - a. Front jewel
 - b. Locking nut
 - c. Wishbone
 - d. Pointer
 - e. Mounting screws (2 req'd)
 - f. Helix assembly (not shown)
 - g. Pivots (2 req'd) (not shown)
 - h. Rear jewel (not shown)
- 230. Zero adjust assembly—consists of:
 - a. Foot screws with washers (2 req'd)
 - b. Adjust screw
 - c. Foot
 - d. Finger
- 260. Scale Assembly—consists of:
 - a. Mounting screws (2 req'd)
 - b. Bumper pointer stop (2 req'd)
 - c. Scale
- 330. Diaphragm Assembly—consists of:
(Arbor press needed to install)
 - a. Linkage assy., complete
 - b. Front plate
 - c. Diaphragm
 - d. Rear plate (not shown)
 - e. Plate washer (not shown)
- 360. Mounting Hardware Kit
 - a. Adapter—pipe plug 1/8" NPT to rubber tubing—(2 req'd)
 - b. Pipe plug 1/8" NPT—(2 req'd)
 - c. Mounting lug (3 req'd)
 - d. Long screw (3 req'd)
 - e. Short screw (3 req'd)

Ordering Instructions:

When corresponding with the factory regarding Magnehelic® gage problems, refer to the call-out numbers in this view. Be sure to include model number, pressure range, and any special options. Field repair is not recommended; contact the factory for repair service information.

Armor-Flo™ benefits

1 Simple design

Armor-Flo™ meters measure the flow rate of a wide range of process fluids. The flow isolated indicator is magnetically coupled to the vane — eliminating contact with wetted parts. May be installed in a vertical or horizontal position.



2 Rugged construction

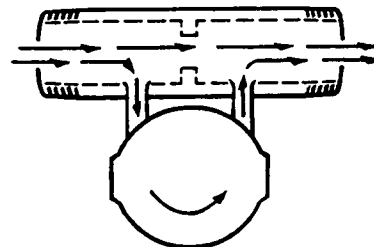
Cast housings with 316 stainless steel fittings stand up to harsh conditions. The Armor-Flo™ housing isolates the fluid. There are no through shafts to leak or wetted glass components. ERDCO® variable area vane flowmeters are shock qualified and meet MIL-S-901B.

3 Flexible

For liquids, gases or saturated steam. Select options that include limit switches and flow proportional 4-20 ma/0-1000 Hz signal outputs. Use with accessory counters for remote digital display of flow rate and total.

4 Low installed cost

Ready to use. Install in-line without saddle clamps, hot taps or electricity. Connection sizes larger than 1 inch include an integral shunt that eliminates the need for special piping.



3200 See-Fi[®] meters

See-Flo[®] meters indicate flow rate and permit visual inspection of water, air or other transparent fluids. For general purpose industrial service, See-Flo[®] meters handle a wide range of process fluids in vertical or horizontal piping runs.

The wedge shape of the meter housing makes See-Flo[®] practically self-cleaning. Where periodic maintenance might be necessary, the tempered glass window is easily removed and replaced.

Direct reading

Each flowmeter is calibrated to be direct reading for a liquid or gas at its operating conditions. 10:1 turndown scale ranges may be selected within the capacity limits by connection size shown on page 7. Scales with special engineering units and dual units of measure are available.

Important features

- Instantaneous rate measurement.
Use in vertical or horizontal piping systems.
- Specify the flow range/units of measure best for your application.
- Economical for pipe connections $\frac{1}{2}$ " to 12".
Observe fluid conditions.

Connections

$\frac{1}{2}$ ", $\frac{3}{4}$ " and 1" female NPT threaded ends. Sizes from $1\frac{1}{4}$ " through 12" include an integral shunt. See page 6 for a complete listing of pipe connection types available. Special sizes and connection types are available on request.



Specifications

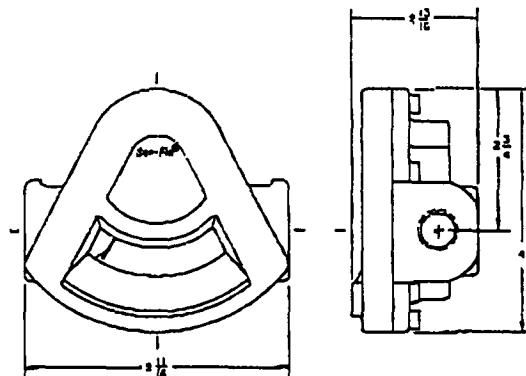
See-Flo meters are variable area/differential pressure flow rate indicators for general purpose industrial application. A sight glass is incorporated in the design to permit process fluid observation. The tempered vane is displaced through the variable area of the triangular meter housing in direct proportion to changes in flow rate/differential pressure. Vane position directly indicates flow rate.

3200 Series meters

| | |
|----------------------------|--|
| Accuracy: | ± 2% full scale |
| Repeatability: | ± 1% full scale |
| Scales: | Direct reading |
| Resolution: | Maximum - 30 divisions Minimum - 15 divisions |
| Rangeability: | 10 to 1 turndown |
| Materials of construction: | (wetted parts) |
| Housing: | Aluminum, brass or 316 stainless steel |
| Shunt: | As housing or carbon steel |
| Window: | Tempered glass or polycarbonate |
| Vane: | 17-7 ph stainless steel — (aluminum & brass housings) Cobalt/chromium/nickel alloy — (316 ss housings) |
| "O" rings: | Buna-n, ethylene propylene, Viton® or Teflon® |
| Piping connections: | ½" to 1" NPT Female 1½" to 4" NPT Male ½" to 3" Tri-clamp 1¼" to 12" Grooved 1¼" to 12" Beveled ½" to 12" 150#/300# RF/FF ANSI Flanges (carbon stl) ½" to 12" 150# RF ANSI Flanges (stainless stl) ½" to 6" 150# RF ANSI Flanges (aluminum) ½" to 6" 150# FF ANSI Flanges (brass) 15 to 25 mm DIN 2999/BS21/ISO R7 Female threaded 15 to 150 mm DIN PN 10 Flanges (316 stainless stl & carbon stl) |
| Pressure limits: | 200 psig (13.8 bar) |
| Temperature limits: | -23 to 85°C (-10 to 185°F) with Teflon® o-ring at constant temperature conditions -23 to 85°C (-10 to 185°F) with polycarbonate window -23 to 121°C (-10 to 250°F) with buna-n o-ring -23 to 204°C (-10 to 400°F) with Viton® or ethylene propylene o-ring |

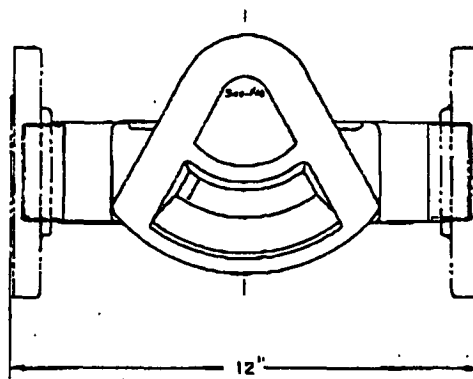
3200 Series

½", ¾" & 1" connections



3200 Series

1¼" to 12" connections



Not intended for use with opaque liquids or steam. ERDCO reserves the right to alter design and/or specifications without notice. Viton® and Teflon® are registered trademarks of E. I. duPont de Nemours and Co.

Meter rangeability

Liquid applications

— specify 10:1 range at or between —

| pipe size | lowest range | | highest range | |
|------------|------------------|------------------------------|------------------|------------------------------|
| | gpm water @ 60°F | pressure drop (psi/gpm rate) | gpm water @ 80°F | pressure drop (psi/gpm rate) |
| ½" - 15 mm | 0.4-4 | 4/4 | 1.5-15 | 3/15 |
| ¾" - 20 mm | 0.5-5 | 1/5 | 3-30 | 5/30 |
| 1" - 25 mm | 0.8-8 | 1.5/8 | 5-50 | 6/50 |
| 1¼" | 2-20 | 2/20 | 15-150 | 8/150 |
| 1½" | 3-30 | 2/30 | 20-200 | 8/200 |
| 2" | 4-40 | 2/40 | 25-250 | 8/250 |
| 2½" | 4-40 | 2/40 | 35-350 | 8/350 |
| 3" | 5-50 | 2/50 | 50-500 | 8/500 |
| 4" | 10-100 | 2/100 | 100-1000 | 8/1000 |
| 5" | 15-150 | 2/150 | 150-1500 | 8/1500 |
| 6" | 25-250 | 2/250 | 200-2000 | 8/2000 |
| 8" | 50-500 | 2/500 | 200-2000 | 8/2000 |
| 10" | 80-800 | 2/800 | 200-2000 | 8/2000 |
| 12" | 100-1000 | 2/1000 | 200-2000 | 8/2000 |

Gas applications

— specify 10:1 range at or between —

| pipe size | lowest range | | highest range | |
|------------|-----------------|---|-----------------|---|
| | scfm air @ 60°F | pressure drop (Inches H ₂ O/scfm rate) | scfm air @ 60°F | pressure drop (Inches H ₂ O/scfm rate) |
| ½" - 15 mm | 1-10 | 2/10 | 2-20 | 3/20 |
| ¾" - 20 mm | 1-10 | 2/10 | 3-30 | 4/30 |
| 1" - 25 mm | 1-10 | 2/10 | 5-50 | 6/50 |
| 1¼" | 1-10 | 2/10 | 15-150 | 8/150 |
| 1½" | 1.5-15 | 2/15 | 20-200 | 8/200 |
| 2" | 2-20 | 2/20 | 25-250 | 8/250 |
| 2½" | 3-30 | 2/30 | 35-350 | 8/350 |
| 3" | 4-40 | 2/40 | 50-500 | 8/500 |
| 4" | 5-50 | 2/50 | 100-1000 | 8/1000 |
| 5" | 6-60 | 2/60 | 150-1500 | 8/1500 |
| 6" | 8-80 | 2/80 | 200-2000 | 8/2000 |
| 8" | 10-100 | 2/100 | 200-2000 | 8/2000 |
| 10" | 15-150 | 2/150 | 200-2000 | 8/2000 |
| 12" | 20-200 | 2/200 | 200-2000 | 8/2000 |

Notes: ■ Units of measure other than gpm and scfm can be specified.

■ When specifying a calibration range consider that the nominal flow value should be approximately at mid-scale.

■ Pressure drop data are typical for maximum flow reading of the range indicated. A flow that causes a midrange reading will have a pressure drop that is a square root function of the pressure drop at full range. Example: An instrument for a 6" piping system that has a range of 200 to 2,000 gpm will have a pressure drop of 8 psi at 2,000 gpm flow and a pressure drop of $\sqrt{8}$ or 2.828 psi at 1,000 gpm on the same scale.

■ Typical pressure drop declines in value in a linear relationship between the maximum of the highest range and maximum of the lowest range. Example: An instrument for a 4" piping system that requires a calibrated range of 40 to 500 gpm will have a typical pressure drop at 500 gpm of 5 psi.

■ Sizes designated mm (millimeters) are available with metric thread in accordance with DIN 2999/BS21/ISO R7.

Model number system

The example 3221-12F5 describes a 3200 Series See-Flo® meter with a brass body/carbon steel shunt for left to right flow. Connections are 3" 150# raised carbon steel flanges.

| <u>32</u> | <u>2</u> | <u>1</u> - | <u>12</u> | <u>F</u> | <u>5</u> |
|-----------|---------------------|----------------|------------------|------------------------|---------------------|
| Series | Housing Material | Flow Direction | Size | Type | Shunt Material |
| 31 — 3100 | 1 — Aluminum | 1 — L to R | 02 — ½" (15 mm) | T — NPT End | 0 — None |
| 32 — 3200 | 2 — Brass | 2 — R to L | 03 — ¾" (20 mm) | R — NPT Back | 1 — Aluminum |
| | 6 — Stainless Steel | 3 — Up | 04 — 1" (25 mm) | S — Tri-clamp | 2 — Brass |
| | | 4 — Down | 05 — 1¼" (32 mm) | G — Grooved | 5 — Carbon Steel |
| | | | 08 — 1½" (40 mm) | X — Beveled | 6 — Stainless Steel |
| | | | 08 — 2" (50 mm) | W — Socket End ½"-1" | |
| | | | 10 — 2½" (65 mm) | F — Flange 150#RF | |
| | | | 12 — 3" (80 mm) | H — Flange 150#FF | |
| | | | 16 — 4" (100 mm) | J — Flange 300#RF | |
| | | | 20 — 5" (125 mm) | K — Flange 300#FF | |
| | | | 24 — 6" (150 mm) | L — Flange DIN PN 10 | |
| | | | 32 — 8" | M — Metric Thread End | |
| | | | 40 — 10" | N — Metric Thread Back | |
| | | | 48 — 12" | | |

ERDCO®

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FM-969-7
Printed in U.S.A.

Appendix B

Field Data Sheets

AIR SPARGING SYSTEM OPERATIONAL INSPECTION AND START SEQUENCE CHECKLIST

| | | |
|---------------|---------|-------|
| EA Personnel: | Date: | Time: |
| Equipment: | ID No.: | |

| PRE-START OPERATIONAL INSPECTION | |
|--|--|
| Air Sparging Process Equipment: | |
| | Confirm accessibility and overall condition of air sparging service vaults in the field |
| | Electrical service confirmed; circuit breakers and control panel energized |
| | Confirm no existing control faults; clear or reset as required |
| | Confirm operation and position of air sparging hand-off-auto switch on control panel |
| | Inspect piping, valves, and fittings for tightness |
| | Confirm air sparging blower lubrication is adequate |
| | Confirm air sparging blower drive belt tension and alignment; confirm proper installation of belt guard |
| | Open diversion valve (to atmosphere) for unloaded start of air sparging blower |
| Air Sparging System Start Sequence: | |
| | Set (AAS) hand-off-auto switch to "Auto" (control panel); depress AAS blower start (control panel) |
| | Partially close diversion valve to divert air to air sparging well heads; do not exceed pressure relief limit (15 psi) |
| | Confirm that pressure and flow are established at appropriate air sparging well head assemblies |
| | Normalize air sparging injection rate |
| | Record operational start time and mechanical/operational parameters in site log |

SOIL VAPOR EXTRACTION SYSTEM OPERATIONAL INSPECTION AND START SEQUENCE CHECKLIST

| | | |
|---------------|---------|-------|
| EA Personnel: | Date: | Time: |
| Equipment: | ID No.: | |

| PRE-START OPERATIONAL INSPECTION | |
|---|--|
| SVE Process Equipment: | |
| | Electrical service confirmed; circuit breakers and control panel energized |
| | Confirm no existing control faults; clear or reset as required |
| | Confirm moisture separator tank empty |
| | Confirm operation and position of SVE hand-off-auto switch on control panel |
| | Adjust SVE influent valving; open valves on SVE risers selected for treatment |
| | Confirm valve settings for remaining SVE process piping (granular activated carbon routing, dilution air) |
| | Inspect piping, valves, and fittings for tightness |
| | Test atmosphere (total volatile hydrocarbons in ppm) in treatment building and in individual SVE risers |
| | Set SVE hand-off-auto switch to "hand;" jog SVE blower motor |
| | Confirm no anomalous SVE blower system noise or vibration |
| SVE System Start Sequence: | |
| | Confirm all valve settings |
| | Set (SVE) hand-off-auto switch to "auto" (control panel) |
| | Confirm that vacuum/flow is established at appropriate SVE manifold risers |
| | Confirm vacuum at appropriate SVE risers in the field |
| | Record operational start time, and mechanical/operational parameters in site log |



EA ENGINEERING,
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AIR SPARGING AND SOIL VAPOR EXTRACTION BLOWER SYSTEM MAINTENANCE OPERATIONAL LOG

| | | |
|---------------|---------|-------|
| EA Personnel: | Date: | Time: |
| Equipment: | ID No.: | |

| Item | Frequency | Action | Date Completed |
|---|--|---|----------------|
| Oil lubrication | First 100 hours; each additional 1,000 hours | Review gear oil per Appendix A | |
| Check/maintain oil level | Bi-Weekly | Add as necessary | |
| Check for noise/vibration (see Table 2-2) | Bi-Weekly | Isolate source and correct | |
| Check relief valve operation | Monthly | Adjust/replace as required. See Note. | |
| Inspect entire system for leaks | Monthly | Refit/tighten/replace components as necessary | |
| Check drive belt tension and alignment | Quarterly | Realign/adjust tension/replace as necessary | |
| Inspect air filters | Quarterly | Clean/replace as required | |
| NOTE: To check relief valve, close dilution valve until relief valve discharges. Check pressure to ensure blowoff occurs at 15 psi. | | | |

SOIL VAPOR EXTRACTION MAINTENANCE OPERATIONAL LOG

| | | |
|---------------|---------|-------|
| EA Personnel: | Date: | Time: |
| Equipment: | ID No.: | |

| Item | Frequency | Action | Date Completed |
|---|--------------|--|----------------|
| Valves | Periodically | Confirm operation, repair, or adjust to ensure proper and safe operation | |
| Piping connections | Periodically | Check piping connections for leaks; tighten as necessary; replace impeller and housing if badly scored | |
| Dilution air intake filters | Quarterly | Check for blockage; clean with compressed air; replace if excessively restricted | |
| In-line soil vapor extraction filter elements | Annually | Replace; more frequent replacement as indicated by vacuum differential across filter unit | |
| Flow sensors (pitot tubes) | As needed | Confirm proper positioning; check for particulate contamination (refer to Appendix A for calibration data) | |
| Temperature gauges | Annually | Inspect stem for accumulation of foreign material (insulating layer); clean as necessary (no servicable parts or adjustments) (refer to Appendix A for specifications/model numbers) | |
| Vacuum gauges | Annually | Inspect stem for cleanliness; compare to known standard gauge | |

FIELD RECORD OF EQUIPMENT CALIBRATION

| | | |
|---------------|-------|---------|
| EA Personnel: | Date: | Time: |
| Equipment: | | ID No.: |

| Parameter | Buffer | Initial Reading | Check/Calibrate |
|--------------|--------|-----------------|-----------------|
| pH | | | |
| pH | | | |
| pH | | | |
| Temperature | | | |
| Conductivity | | | |
| D.O. | | | |
| Redox | | | |

| TVA 1000 | Calibration Gas (ppm) | Initial Reading | Check/Calibrate |
|-----------------|--------------------------|-----------------|-----------------|
| PID | | | |
| FID | | | |
| Comments: _____ | | | |
| | | | |
| | | | |
| | | | |
| | | | |

FIELD RECORD OF AIR SPARGING WELL POINT MONITORING

Air Sparging System, Old Navy Fuel Farm, Naval Air Station, Brunswick Maine

| | | |
|---------------|----------------|-------|
| EA Personnel: | Date: | Time: |
| Weather: | Instrument(s): | |

| Location | FID TVH (ppm _v) | PID TVH (ppm _v) | CH ₄ | CO ₂ | O ₂ | Comments |
|----------|--------------------------------|-----------------------------------|-----------------|-----------------|----------------|----------|
| WP-1 | | | | | | |
| WP-2 | | | | | | |
| WP-3 | | | | | | |
| WP-4 | | | | | | |
| WP-5 | | | | | | |
| WP-6 | | | | | | |
| WP-7 | | | | | | |
| WP-8 | | | | | | |
| WP-9 | | | | | | |
| WP-10 | | | | | | |
| WP-11 | | | | | | |
| WP-12 | | | | | | |
| WP-13 | | | | | | |
| WP-14 | | | | | | |
| WP-15 | | | | | | |
| WP-16R | | | | | | |
| WP-17R | | | | | | |
| WP-18R | | | | | | |
| WP-19 | | | | | | |
| WP-20 | | | | | | |
| WP-21 | | | | | | |
| WP-22 | | | | | | |

FIELD RECORD OF WELL GAUGING, PURGING, AND SAMPLING

| | | |
|--|---------------|-------|
| Project Name: | Project No.: | Date: |
| EA Personnel: | Purge Method: | |
| Weather/Temperature/Barometric Pressure: | | Time: |

| | |
|---------------------------------|-----------------------------------|
| Well No.: | Well Condition: |
| Well Diameter: | Measurement Reference: |
| Well Volume Calculations | |
| A. Depth to Water (ft): | D. Well Volume/ft: |
| B. Total Well Depth (ft): | E. Total Well Volume (gal) [C*D]: |
| C. Water Column Height (ft): | F. Five Well Volumes (gal): |

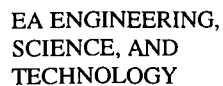
| Parameter | Beginning | 1 Volume | 2 Volumes | 3 Volumes | 4 Volumes | 5 Volumes |
|--|-----------|----------|-----------|-----------|-----------|-----------|
| Time (minutes) | | | | | | |
| Depth to Water (ft) | | | | | | |
| Purge Rate (gpm) | | | | | | |
| Volume Purged (gal) | | | | | | |
| pH | | | | | | |
| Temperature (°C) | | | | | | |
| Conductivity (μmhos/cm) | | | | | | |
| Dissolved Oxygen (mg/L) | | | | | | |
| eH (mV) | | | | | | |
| TOTAL QUANTITY OF WATER REMOVED (gal): _____ | | | | | | |
| COMMENTS AND OBSERVATIONS: _____ | | | | | | |
| _____ | | | | | | |
| _____ | | | | | | |
| _____ | | | | | | |

FIELD RECORD OF WATER QUALITY PARAMETER ANALYSIS

Air Sparging System, Old Navy Fuel Farm, Naval Air Station, Brunswick Maine

| | | |
|---------------|------------|-------|
| EA Personnel: | Date: | Time: |
| Weather: | Equipment: | |

| Location | Depth to Water (ft) | Depth to Product (ft) | pH | Temperature (°C) | Dissolved Oxygen (mg/L) | Conductivity (μhmos) | Redox (mV) | Bottom |
|----------|---------------------|-----------------------|----|------------------|-------------------------|----------------------|------------|--------|
| WP-1 | | | | | | | | |
| WP-2 | | | | | | | | |
| WP-3 | | | | | | | | |
| WP-4 | | | | | | | | |
| WP-5 | | | | | | | | |
| WP-6 | | | | | | | | |
| WP-7 | | | | | | | | |
| WP-8 | | | | | | | | |
| WP-9 | | | | | | | | |
| WP-10 | | | | | | | | |
| WP-11 | | | | | | | | |
| WP-12 | | | | | | | | |
| WP-13 | | | | | | | | |
| WP-14 | | | | | | | | |
| WP-15 | | | | | | | | |
| WP-16R | | | | | | | | |
| WP-17R | | | | | | | | |
| WP-18R | | | | | | | | |
| WP-20 | | | | | | | | |
| WP-21 | | | | | | | | |
| WP-22 | | | | | | | | |



FIELD RECORD OF WATER QUALITY PARAMETER ANALYSIS

Air Sparging System, Old Navy Fuel Farm, Naval Air Station, Brunswick Maine

| | | |
|---------------|------------|-------|
| EA Personnel: | Date: | Time: |
| Weather: | Equipment: | |

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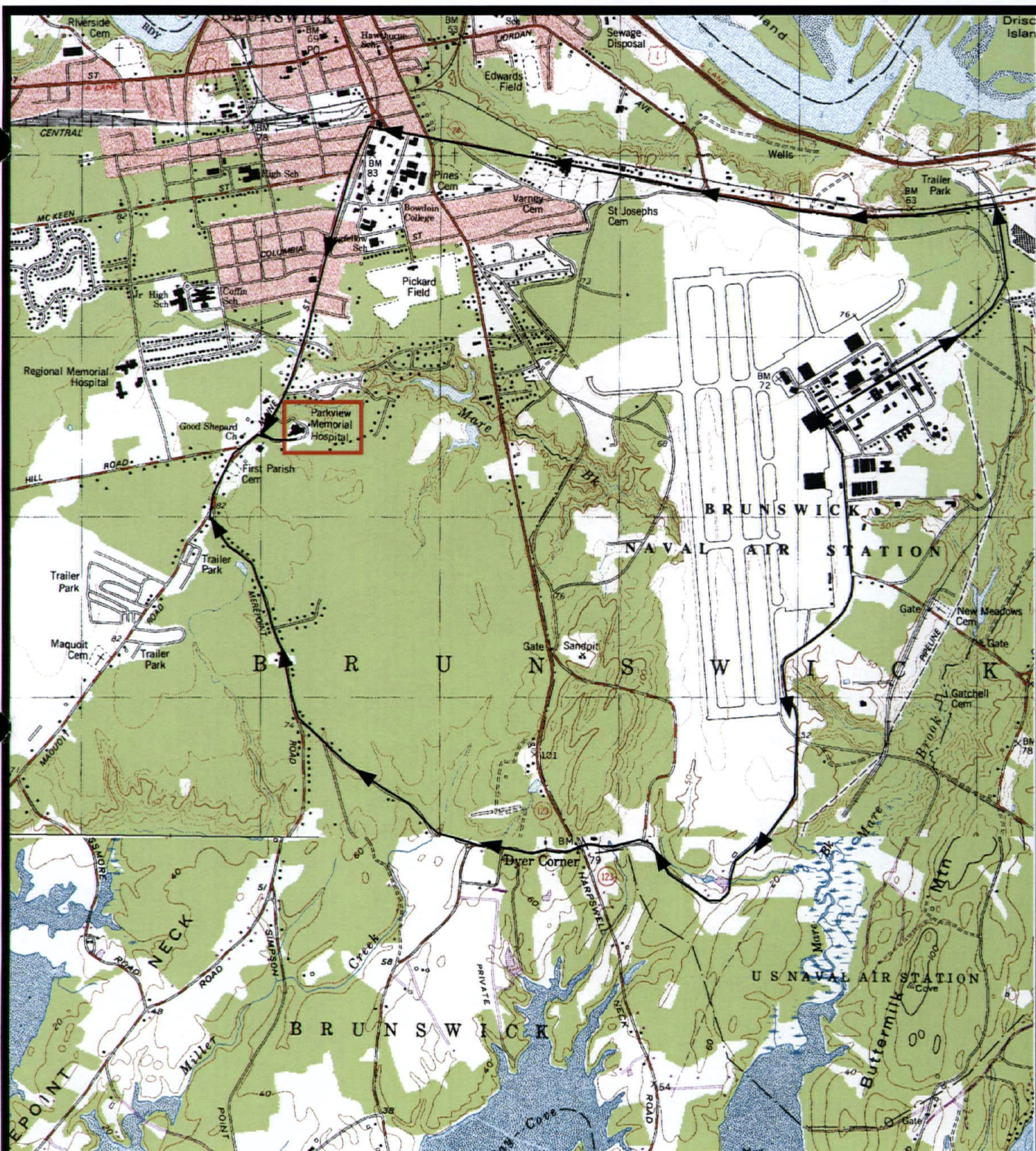
Appendix C

Emergency Contact and Technical Support Telephone Numbers

APPENDIX C

EMERGENCY CONTACT AND TECHNICAL SUPPORT
TELEPHONE NUMBERS

| SITE: Old Navy Fuel Farm, Naval Air Station, Brunswick | |
|---|--------------------------|
| Emergency Contact | Telephone Number |
| NAS Brunswick Facility Emergency Response Coordinator | (207) 921-3333 |
| NAS Brunswick Public Works, Environmental Division | (207) 921-2445 |
| Police | 911 |
| Fire | 911 |
| Ambulance | 911 |
| Hospital: Parkview Memorial Hospital Maine Street Brunswick, Maine | (207) 729-1641 (General) |
| Directions to Hospital: Follow Second Street, turn right onto Fitch Avenue, proceed to main gate, exit from gate, turn left onto Route 24, proceed 1 mi to Main Street, then left on Main Street, proceed 1 mi, Parkview Hospital is on left. | |
| Poison Control Center | (800) 492-2414 |
| Emergency Personnel Contact | Telephone Number |
| EA Program Safety and Health Officer <i>Kris Hoiem, CIH</i> | (410) 771-4950 |
| Program Manager <i>Charles Flynn</i> | (410) 771-4950 |
| Project Manager <i>John Carnright</i> | (914) 565-8100 |
| Site Leader/Site Safety and Health Officer <i>Suzanne Chase</i> | (207) 798-5977 |
| Treatment Plant Operator <i>Michael Chase</i> | (207) 798-5977 |
| In case of accident or exposure incident, contact <i>Kris Hoiem, CIH</i> | (410) 771-4950 |
| Environmental Coordinator, NAS PW-ENV <i>Greg Apraham</i> | (207) 921-1720 |
| IRP Coordinator | (207) 921-1719 |



500 0 500 1000 Meters



EA ENGINEERING,
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NAVAL AIR STATION
BRUNSWICK, MAINE

EMERGENCY ROUTES TO
PARKVIEW MEMORIAL HOSPITAL

PROJECT MGR

CEM

DESIGNED BY

BT

DRAWN BY

BT

CHECKED BY

CEM

SCALE

AS SHOWN

DATE

17 FEB 1999

PROJECT No

29600.35

FILE No

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NAVY.APR